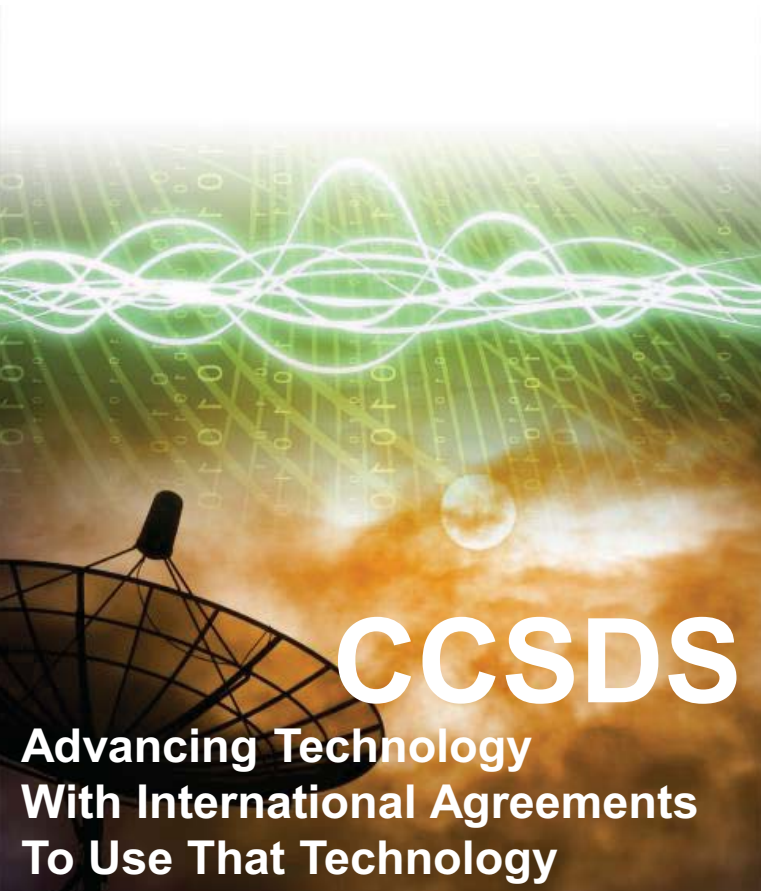


# CCSDS Overview

**Presentation to NSPO in Taiwan  
November 2013**



**Mike Kearney**  
CCSDS Chair & General Secretary  
NASA MSFC EO-01  
256-544-2029  
[Mike.Kearney@nasa.gov](mailto:Mike.Kearney@nasa.gov)

# Agenda

---

- ✦ CCSDS Background (scope, participation, etc.)
- ✦ CCSDS Architecture, Organization, Processes
- ✦ Access to CCSDS Online
- ✦ CCSDS Strategic Goals by Technical Area
- ✦ Closeup on CCSDS Activities in Select Working Groups

Advancing Technology  
*simultaneous* with international agreements  
to use that technology

# CCSDS – Scope and Origins

- ✦ CCSDS = The Consultative Committee for Space Data Systems
- ✦ The primary goal of CCSDS is **interoperability** between communications and data systems of space agencies' vehicles, facilities, missions and programs.
- ✦ Of all of the technologies used in spaceflight, standardization of **communications and data systems** brings the most benefit to multi-agency interoperability.
- ✦ CCSDS Started in 1982 developing standards at the lower layers of the protocol stack. The CCSDS scope has grown to cover standards throughout the entire ISO communications stack, plus other Data Systems areas (architecture, archive, security, XML exchange formats, etc).





# On CCSDS Standards

## MYTH

Standards stifle innovation

## FACT

CCSDS stimulates advanced technology by adopting, adapting, developing and solidifying innovations with exposure to a wider community

When an innovative technology is rapidly brought to the standards community, it is vetted with a larger user base, facilitating widespread adoption of innovative technology.

This reduces the risk of new technology with “more eyes on the problem.”

This spreads the cost of technology development over a larger user base.

This enables joint missions, for cost sharing and increased capabilities.

This improves operations, with familiar interfaces and more options for contingency recovery.

## MYTH

Standards delay implementation

## FACT

Not if the innovation is brought into the standards process early. Delays result from reluctance to standardize, not from standardization



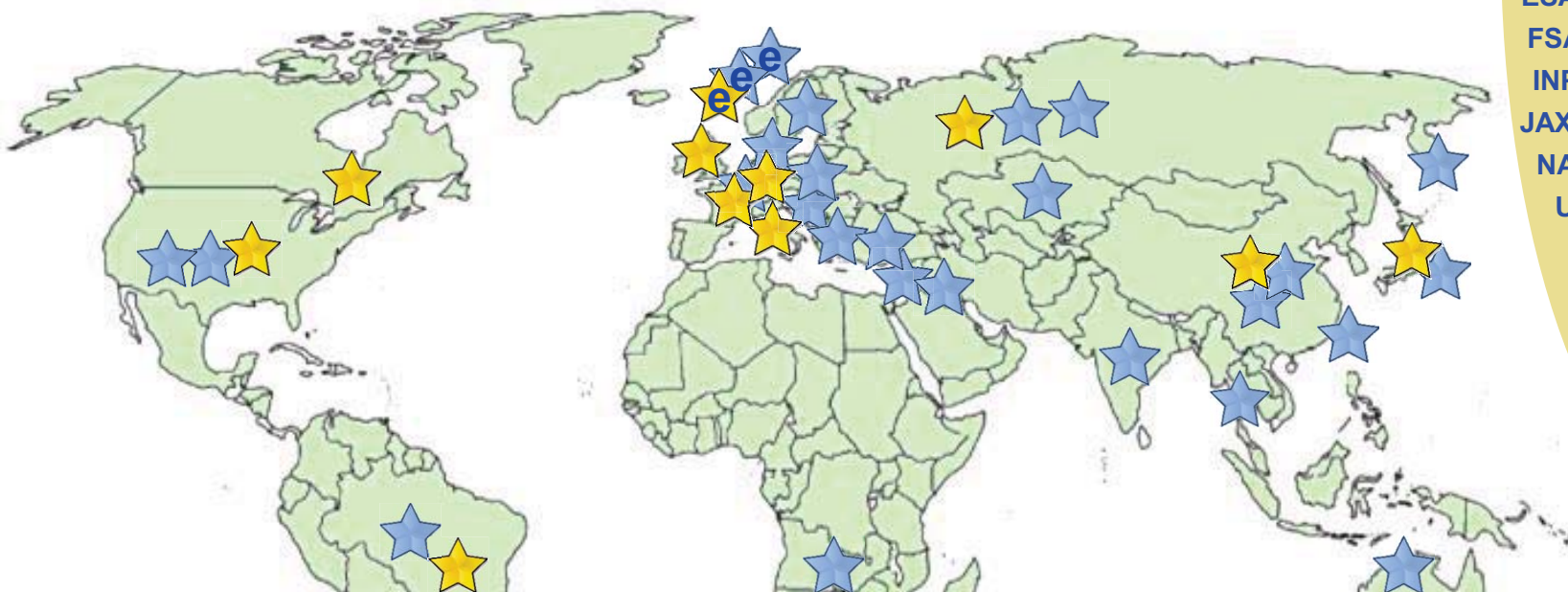
# CCSDS Overview - Participation

## ★ CCSDS – An Agency-Led International Committee

- ✧ Currently 11 Member agencies
- ✧ Currently 28 Observer Agencies
- ✧ Agencies represent 26 nations
- ✧ Currently 151 Commercial Associates
- ✧ ~160-180 attendees at Spring/Fall meetings

## ★ Also functions as an ISO Subcommittee

- ✧ TC20/SC13 - Space Data & Info Transfer Systems
- ✧ Represents 20 nations



### OBSERVER AGENCIES



### MEMBER AGENCIES

**ASI/Italy** DCTA/Brazil  
**CNES/France** DNSC/Denmark  
**CNSA/China** EUMETSAT/Europe  
**CSA/Canada** EUTELSAT/Europe  
**DLR/Germany** GISTDA/Thailand  
**ESA/Europe** HNSC/Greece  
**FSA/Russia** IKI/Russia  
**INPE/Brazil** ISRO/India  
**JAXA/Japan** KARI/Korea  
**NASA/USA** KFKI/Hungary  
**UKSA/UK** MOC/Israel  
 NCST/USA  
 NICT/Japan  
 NOAA/USA  
 NSARK/Kazakhstan  
 NSPO/Taipei  
 SSC/Sweden  
 SUPARCO/Pakistan  
 TsNIIMash/Russia  
 TUBITAK/Turkey  
 USGS/USA

# CCSDS Overview

## End-to-End Architecture

### Six Technical Areas, Twenty-Nine Teams

- ◆ Working Group (producing standards)
- ◆ Birds-Of-a-Feather stage (pre-approval)
- ◆ Special Interest Group (integration forum)

#### Systems Engineering

- ◆ Security
- ◆ Space Assigned Numbers Auth.
- ◆ Delta-DOR
- ◆ Timeline Data Exchange
- ◆ XML Standards and Guidelines

### Typical Mission Profile



#### Spacecraft Onboard Interface Services

- ◆ Onboard Wireless WG
- ◆ Application Supt Services (incl. Plug-n-Play)

#### Space Link Services

- ◆ RF & Modulation
- ◆ Space Link Coding & Sync.
- ◆ Multi/Hyper Data Compress.
- ◆ Space Link Protocols
- ◆ Next Generation Uplink
- ◆ Space Data Link Security
- ◆ Planetary Communications
- ◆ Optical Coding and Mod

#### Cross Support Services

- ◆ CS Service Management
- ◆ CS Transfer Services
- ◆ Cross Supt Service Arch.
- ◆ Generic Gnd-to-Gnd File Transfer

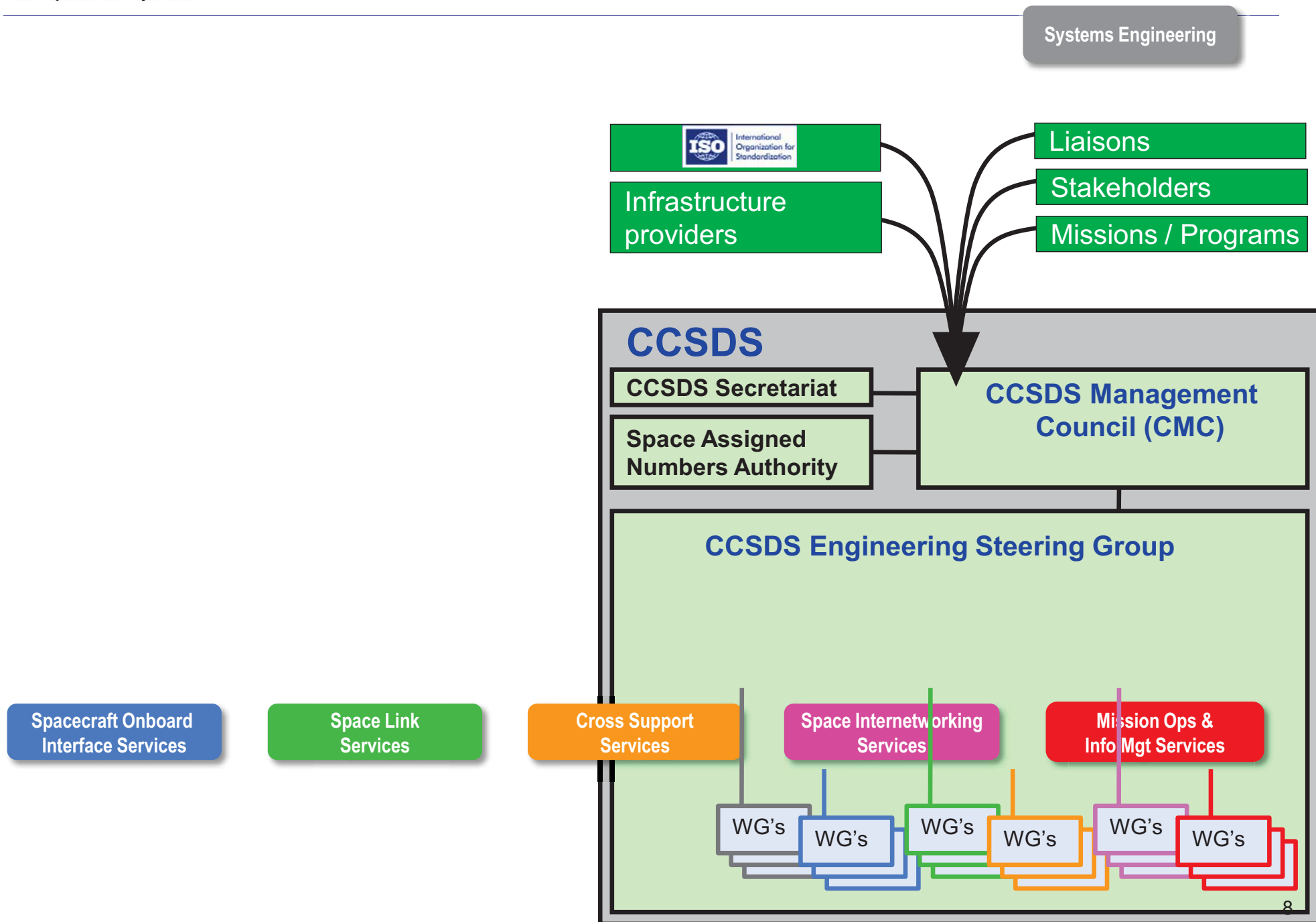
#### Space Internetworking Services

- ◆ Motion Imagery & Apps
- ◆ Delay Tolerant Networking
- ◆ Voice
- ◆ CFDP over Encap
- ◆ CFDP Revisions

#### Mission Ops & Info Mgt Services

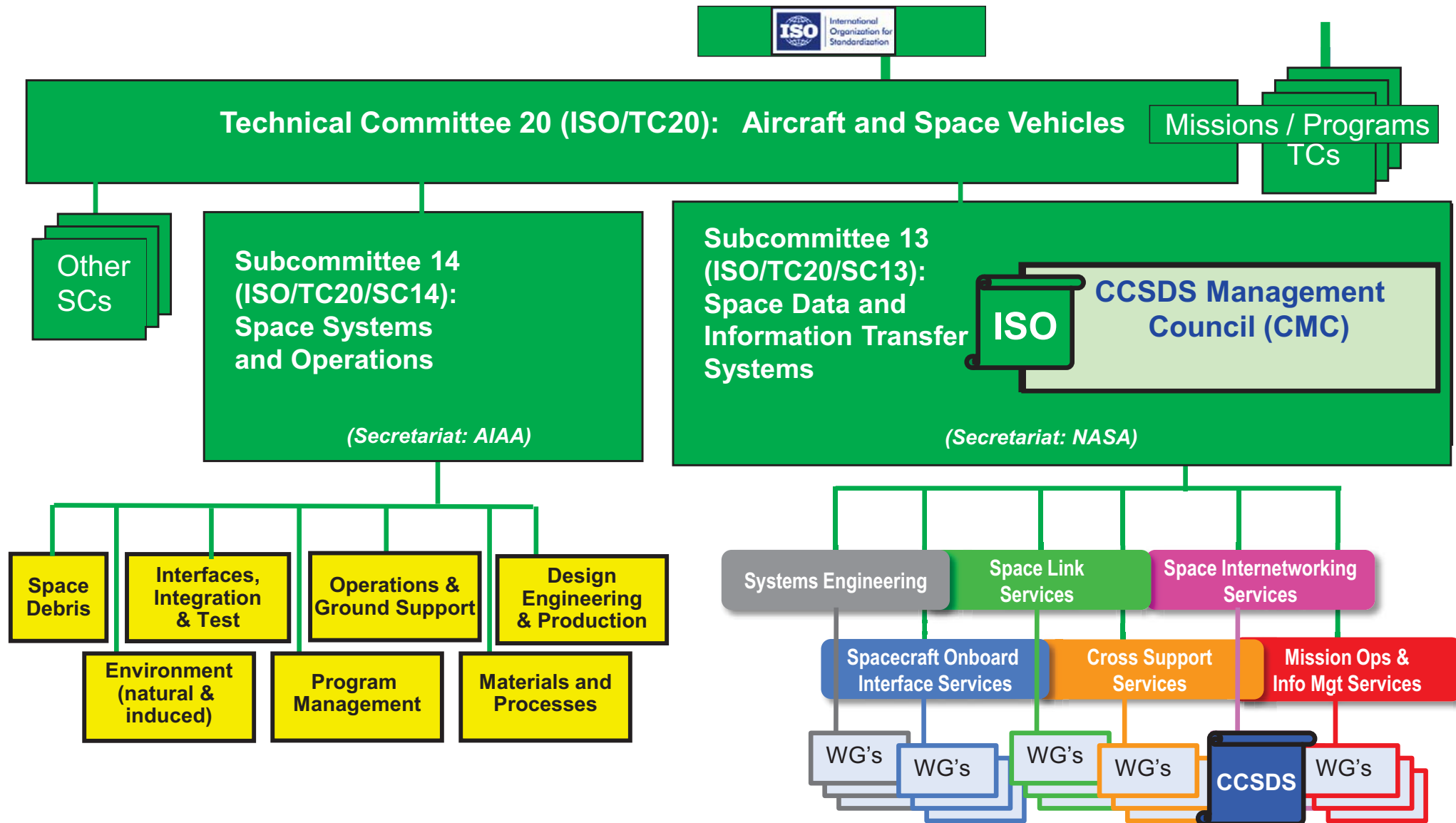
- ◆ Data Archive Ingestion
- ◆ Navigation
- ◆ Spacecraft Monitor & Control
- ◆ Digital Repository Audit/Certification
- ◆ Telerobotics

# CCSDS Structure and Organization





# CCSDS Relationships with ISO



# CCSDS Strategic Plan

## The CCSDS Plan for the Future

1. Towards Cross-cutting functions and coherent architecture-wide integration
2. Towards standardized Onboard Interfaces and Services
3. Towards Standardized Mission Operations Services and complete Navigation Message Standardization
4. Towards an extensible Space Communications Cross Support Service Management and Transfer Services (Cross Support of Communications Assets)
5. Towards an unified Space Data Link Protocol, optical links, new sync and compression
6. Towards standardized Space System Internetworking Services and the Solar System Internet (SSI)

Systems Engineering

Space Link  
Services

Space Internetworking  
Services

Spacecraft Onboard  
Interface Services

Cross Support  
Services

Mission Ops &  
Info Mgt Services

# Future Mission Drivers

**PAST**

**PRESENT**

**DRIVERS FOR THE**

**FUTURE**



**Shuttle/SpaceLab**  
CCSDS packets



**Brief Recon Flyby,**  
Short-Lived Probes  
Direct-to-Earth links



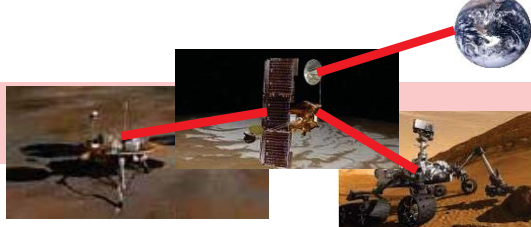
**Single-Spacecraft**  
Survey/Sensors



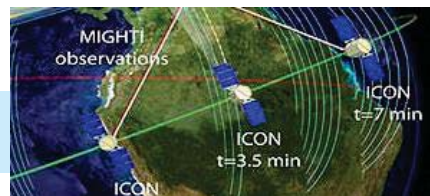
**Single-Spacecraft**  
Observatories in LEO



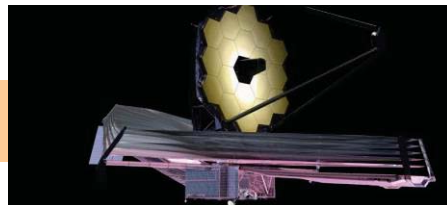
**International Space Station**  
Adv. Orbital Sys (AOS)  
Early DTN Prototyping



**Missions designed for orbital relays,**  
Longer duration



**Spacecraft Constellations**  
and formation flying



**Greater Distances**  
Higher bandwidth

## In Situ Exploration

- Human Expeditions
- Long Duration, High Reliability
- Mobile comm protocols
- Voice, Video, Medical handling
- Onboard Autonomy
- Highly integrated ops

## Complex Deep Space Missions

- Human or robotic exploration
- Longer Duration
- Mobile comm protocols
- Fully automated routing
- Network-Managed DTN
- Optical Communications

## Orbital Remote Sensing

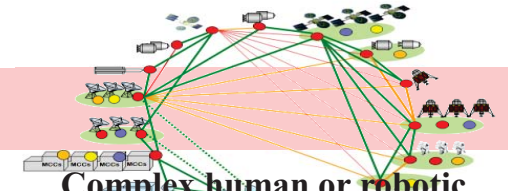
- Long Duration, high bandwidth
- High Spatial, Spectral, & Temporal Resolution
- Low Latency Comm
- Complex link topologies
- *SensorWebs* for synchronized remote sensing

## Next Generation Observatories

- More Capability
- Multiple Spacecraft drive network needs
- Even Greater Capacities require new coding schemes
- Located Even Farther from Earth



**Asteroid/Surface Exploration**  
Autonomy, High bandwidth  
Multi-Agency Mission Ops



**Complex human or robotic**  
Scenarios for remote surface missions  
Fully automated Space Internetworking



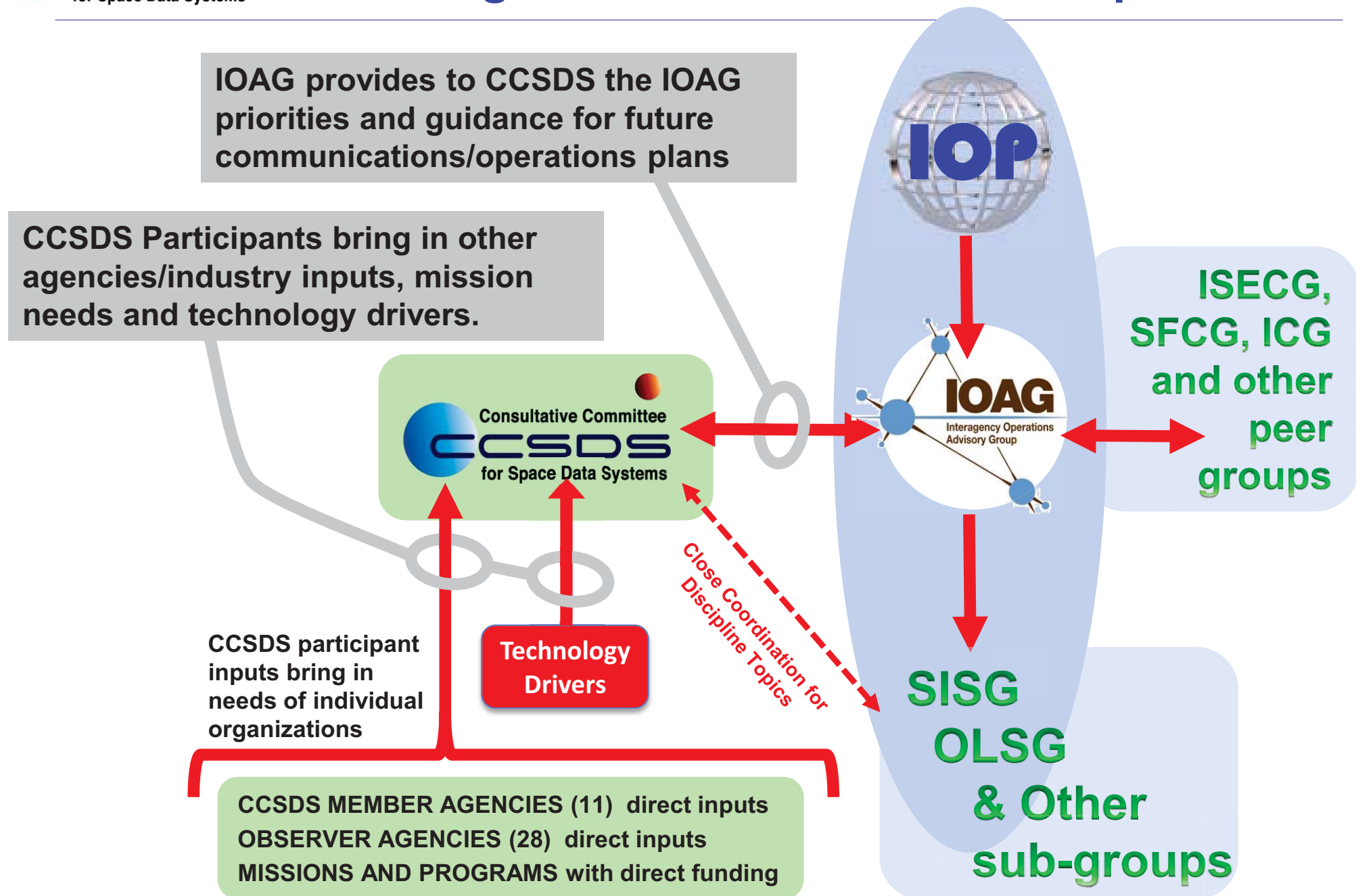
**Multi-Discipline and**  
Multi-Resource SensorWebs



**Next Generation**  
Observatory Complexes

# CCSDS Overview

## Organizational Interrelationships





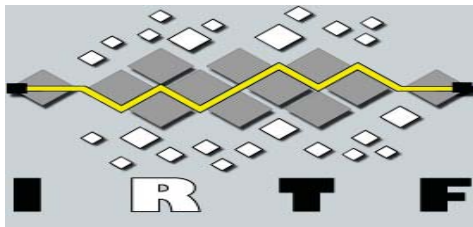
# Some Organizational Interrelationships



## OMG: Object Management Group

Industry standards for exchange of application information among vendor products

CCSDS/OMG have some common standards and periodic joint meetings

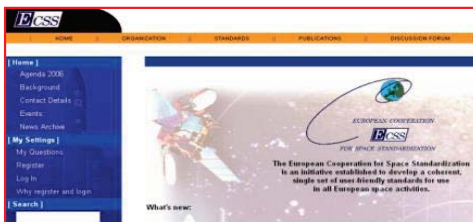


## IETF: Internet Engineering Task Force

## IRTF: Internet Research Task Force

Open international standards for IP suite and DTN

CCSDS uses such industry standards as a basis, whenever possible



## ECSS: European Consortium for Space Standards -

European regional standards for space mission support

CCSDS/ECSS coordinate on compatible standards



## AIAA: American Institute of Aeronautics and Astronautics

North American regional standards for space mission support

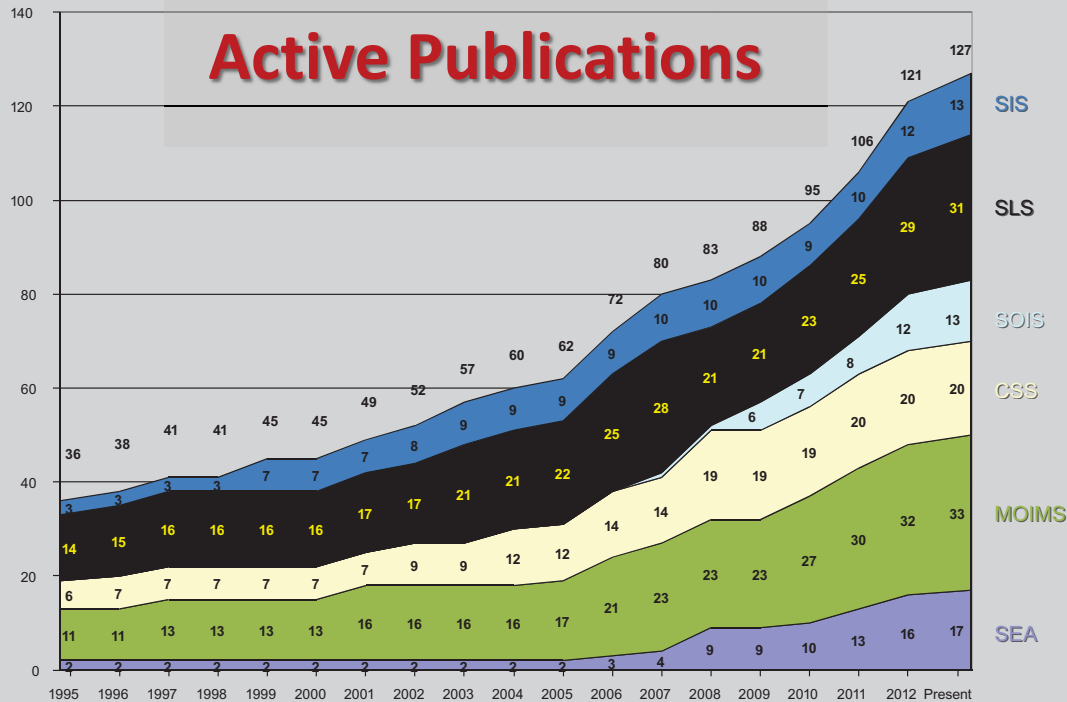
Regional Standards coordination, and AIAA provides Secretariat support for CCSDS, ISO TC20/SC13 and SC14



# CCSDS Overview

## Adoption by Missions

### Active Publications



**Currently Active Publications: 127**

**Normative: 78**

**Informative: 49**

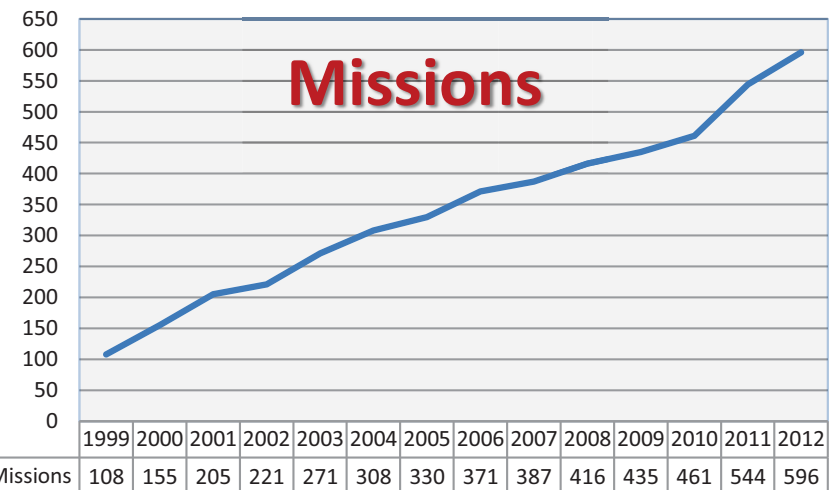
Downloadable for free from

[www.ccsds.org](http://www.ccsds.org)

**All major pubs since 1982: 275**

**Some were historical mission needs or superseded technology**

**609** space missions have adopted and used various CCSDS standards






2009	28 (done)
2010	36 (done)
2011	35 (done)
2012	53 (done)
2013	64 (planned)
2014	17 (planned)
2015	12 (planned)

## More efforts expected in the future.

**When will CCSDS be done?**  
**When technology stops changing.**

# Access to CCSDS Publications

## [www.ccsds.org](http://www.ccsds.org) > Publications



[About](#) [Publications](#) [Review Documents](#) [Meetings](#) [Press Room](#) [Participation](#) [Implementations](#) [Search](#)

### CCSDS Approved Documents

- ▶ [Blue: Recommended Standards](#)
- ▶ [Magenta: Recommended Practices](#)
- ▶ [Green: Informational Reports](#)
- ▶ [Orange: Experimental](#)
- ▶ [Yellow: Required](#)
- ▶ [Silver: Historical](#)
- ▶ [All Active Publications](#)


### Other

- ▶ [Review Documents](#)
- ▶ [Reference Models](#)
- ▶ [Non-English Versions of Documents](#)

## Blue Books: Recommended Standards


CCSDS Recommended Standards (Blue Books) define specific interfaces, technical capabilities or protocols, or provide prescriptive and/or normative definitions of interfaces, protocols, or other controlling standards such as encoding approaches. Standards must be complete, unambiguous and at a sufficient level of technical detail that they can be directly implemented and used for space mission interoperability and cross support. Standards must say very clearly, "this is how you must build something if you want it to be compliant".

### Currently 47 Books Listed




**[CCSDS 121.0-B-1](#)**  
File size: 256,280 Bytes

***Lossless Data Compression. Blue Book. Issue 1. May 1997.***  
This Recommendation defines a source-coding data-compression algorithm and specifies how data compressed using the algorithm are inserted into source packets for retrieval and decoding. This document has been reconfirmed by the CCSDS Management Council through November 2011. The current version of this document contains all updates through Technical Corrigendum 2, dated September 2007.  
ISO Number : 15887




**[CCSDS 121.0-B-1 Cor. 1](#)**  
File size: 84,329 Bytes

***Technical Corrigendum 1 to CCSDS 121.0-B-1, Issued May 1997. Blue Book. Issue 1 Cor. 1. November 2006.***  
This Technical Corrigendum documents changes to CCSDS 121.0-B-1, Lossless Data Compression (Blue Book, Issue 1, May 1997)



**[CCSDS 121.0-B-1 Cor. 2](#)**  
File size: 19,978 Bytes

***Technical Corrigendum 2 to CCSDS 121.0-B-1, Issued May 1997. Blue Book. Issue 1 Cor. 2. September 2007.***  
This Technical Corrigendum documents changes to CCSDS 121.0-B-1, Lossless Data Compression (Blue Book, Issue 1, May 1997)



**[CCSDS 122.0-B-1](#)**  
File size: 1,121,448 Bytes

***Image Data Compression. Blue Book. Issue 1. November 2005.***  
This Recommended Standard defines an image-data compression algorithm applicable to digital data from payload instruments and specifies means to control compression rate and how



# Field Guide to CCSDS Book Colors



## BLUE BOOKS

### Recommended Standards

Normative and sufficiently detailed (and pre-tested) so they can be used to directly and independently implement interoperable systems (given that options are specified).



## ORANGE BOOKS

### Experimental

Normative, but may be very new technology that does not **yet** have consensus of enough agencies to standardize.



## MAGENTA BOOKS

### Recommended Practices

Normative, but at a level that is not directly implementable for interoperability. These are Reference Architectures, APIs, operational practices, etc.



## YELLOW BOOKS

### Administrative

CCSDS Procedures, Proceedings, Test reports, etc.



## GREEN BOOKS

### Informative Documents

Not normative. These may be foundational for Blue/Magenta books, describing their applicability, overall architecture, ops concept, etc.



## SILVER BOOKS

### Historical

Deprecated and retired documents that are kept available to support existing or legacy implementations. Implication is that other agencies may not cross-support.



## RED BOOKS

### Draft Standards/Practices

Drafts of future Blue/Magenta books that are in agency review. Use caution with these... they can change before release.



## PINK BOOKS/SHEETS

### Draft Revisions For Review

Draft Revisions to Blue or Magenta books that are circulated for agency review. Pink Books are reissues of the full book, Pink Sheets are change pages only.

# Access to CCSDS Technical WG info: [www.ccsds.org](http://www.ccsds.org) > CWE

Welcome to  
the CCSDS  
Collaborative  
Work  
Environment  
(CWE)

The interactive graph to the right represents the CCSDS Technical Organization. The CCSDS Engineering Group (CESG) is composed of 6 areas. Within these areas there are Working Groups (WG), Birds of a Feather (BOF), and Special Interest Groups (SIG) that collaborate.

To access more information please click on the CMC, CESG, Area, WG, or BOF name.

To review the status of documents and projects being developed in these WGs, [Click Here](#).

## CCSDS Technical Organization

### CCSDS Management Council (CMC)

General Secretary: Mike Kearney

CMC DOCUMENTS

CMC POLLS

### CCSDS Engineering Steering Group (CESG)

CESG Chair: Adrian Hooke

CESG DOCUMENTS

CESG POLLS

#### Systems Engineering Area (SEA)

AD: Peter M. Shames

##### SEA DOCUMENTS

**Information Architecture Working Group (SEA-IA)**  
Chair: Daniel J. Crichton

**Security Working Group (SEA-SEC)**  
Chair: Howard Weiss

**SEA SANA Working Group (SEA-SANA)**  
Chair: Marc Blanchet

**Delta-DOR Working Group (SEA-D-DOR)**  
Chair: Roberto Maddè

**Time Code Formats Working Group (SEA-TIME)**  
Chair: Ed Greenberg

*Time Correlation*

#### Mission Operations and Information Management Services Area (MOIMS)

AD: Nestor Peccia

##### MOIMS DOCUMENTS

**Data Archive Ingestion Working Group (MOIMS-DAI)**  
Chair: John Garrett

**Navigation Working Group (MOIMS-NAV)**  
Chair: David Berry

**Information Packaging & Registries Working Group (MOIMS-IPR)**  
Chair: Louis I. Reich

**Spacecraft Monitor and Control Working Group (MOIMS-SM&C)**  
Chair: Mario Merri

**The Digital Repository**

#### Cross Support Services Area (CSS)

AD: Erik Barkley

##### CSS DOCUMENTS

**Service Management Working Group (CSS-SM)**  
Chair: Erik Barkley

**Transfer Services Working Group (CSS-CSTS)**  
Chair: Margherita di Giulio

**Cross Support Space Communications Architecture Working Group (CSS-CSA)**  
Chair: Takahiro Yamada

*CCSDS Reference Architecture Special Interest Group (CSS-RASG)*  
Chair: Erik Barkley

#### Spacecraft Onboard Interface Services Area (SOIS)

AD: Chris Taylor

##### SOIS DOCUMENTS

**Application Support Services Working Group (SOIS-APP)**  
Chair: Stuart Fowell

**Onboard Wireless Working Group (SOIS-WIR)**  
Chair: Patrick Plancke

*Onboard Plug & Play Birds of a Feather (SOIS-OPP)*  
Chair: Stuart Fowell

#### Space Link Services Area (SLS)

AD: Jean-Luc Gerner

##### SLS DOCUMENTS

**RF Modulation Working Group (SLS-RFM)**  
Chair: Enrico Vassallo

**Space Link Coding and Synchronization Working Group (SLS-C&S)**  
Chair: Gian Paolo Calzolari

**Multispectral Hyperspectral Data Compression Working Group (SLS-MHDC)**  
Chair: Aaron Kiely

**Space Link Protocols Working Group (SLS-SLP)**  
Chair: Greg Kazz

**Next Generation Uplink Working Group (SLS-NGU)**  
Chair: Greg Kazz

**Space Data Link**

#### Space Internetworking Services Area (SIS)

AD: Robert Durst

##### SIS DOCUMENTS

**Packet Protocol Working Group (SIS-SPP)**  
Chair: Dai Stanton

**Asynchronous Message Service Working Group (SIS-AMS)**  
Chair: Scott C. Burleigh

**IP Over CCSDS Working Group (SIS-IP0)**  
Chair: Greg Kazz

**Motion Imagery and Applications Working Group (SIS-MIA)**  
Chair: Rodney Grubbs

**Delay Tolerant Networking Working Group (SIS-DTN)**  
Chair: Keith





**CCSDS.ORG**

Advance.

About Publications Review Documents Meetings Press Room Participation Implementations Search

**Headlines**

- 2012 Spring CCSDS Meetings Information (March 7, 2012)
- NASA MESSENGER Spacecraft Sends Data from Mercury Using CCSDS Protocol (March 30, 2011)
- Recently Released Documents
- Enter Press Room

**Events**

- CCSDS Meetings
- Conferences

**Number Assignments**

- Space Assigned Numbers Authority (SANA)
- Spacecraft ID
- Control Authority

**Related Organizations**

- Interagency Operations Advisory Group (IOAG)
- ISO TC20/SC13 Subcommittee Contents

**The Consultative Committee for Space Data Systems**  
The Official Web Site

**Welcome to CCSDS.org**

Founded in 1982 by the major space agencies of the world, the CCSDS is a multi-national forum for the development of communications and data systems standards for spaceflight.

Today, leading space communications experts from 30 nations collaborate in developing the most well-engineered space communications and data handling standards in the world.

The goal? To enhance governmental and commercial interoperability and cross-support, while also reducing risk, development time and project costs.

More than 500 space missions have chosen to fly with CCSDS-developed standards, and the number continues to grow.

**Interested in CCSDS?**

- Click "Publications" above to visit the library of CCSDS standards.
- Click "Review Documents" above to see what documents are currently under CCSDS agency review.
- Click "CWE" (upper right) to see a map of working groups and access information to contact working group chairs.
- Questions you don't see answered on our website? [Ask Here](#)

Thank you for your interest in the CCSDS.

**New Work Item Announcements**  
Find out about new initiatives and technology developments that you can contribute to, and you missions can benefit from.

**The CCSDS Blog**  
General events, meetings, new publications etc.

**Quick Links**  
Existing users [Sign In here.](#)

**CWE**  
Collaborative Work Environment  
Visitors: Enter the [CWE area](#) to view public documents in the CCSDS working teams. Request a [CWE ID](#) to fully engage in the Technical teams. Request login [here.](#)

**MAILMAN**  
Visit the [CCSDS Mailman page](#) to Sign up for mail lists in technical areas Of your expertise. Then engage with Other experts and contribute!

**New Work Item Announcements**

**The CCSDS Blog – General Announcements**

**Under Construction: The CCSDS WIKI**  
Soon to come

# **CCSDS Strategic Goals by Technical Area**

# CCSDS Strategic Plan

## The CCSDS Plan for the Future

---

Systems Engineering

**1. Towards Cross-cutting functions and coherent architecture-wide integration**

Spacecraft Onboard  
Interface Services

**2. Towards Standardized Onboard Interfaces and Services**

Mission Ops &  
Info Mgt Services

**3. Towards Standardized Mission Operations Services and complete Navigation Message Standardization**

Cross Support  
Services

**4. Towards an Extensible Space Communications Cross Support Service Management and Transfer Services (Cross Support of Communications Assets)**

Space Link  
Services

**5. Towards a Unified Space Data Link Protocol, optical links, new sync and channel coding schemes and compression**

Space Internetworking  
Services

**6. Towards Standardized Space System Internetworking Services and the Solar System Internet (SSI)**

# Systems Engineering Area Goals

Systems Engineering

1.

Define cross-cutting functions and end-to-end system architectures, in support of interoperability and cross support, overarching and underpinning the above goals and that facilitate addressing global challenges, including:

- ✧ Cyber security;
- ✧ Reference system architectures;
- ✧ Information models and architectures;
- ✧ Systems-of-systems interoperability;
- ✧ CCSDS support services and capabilities.

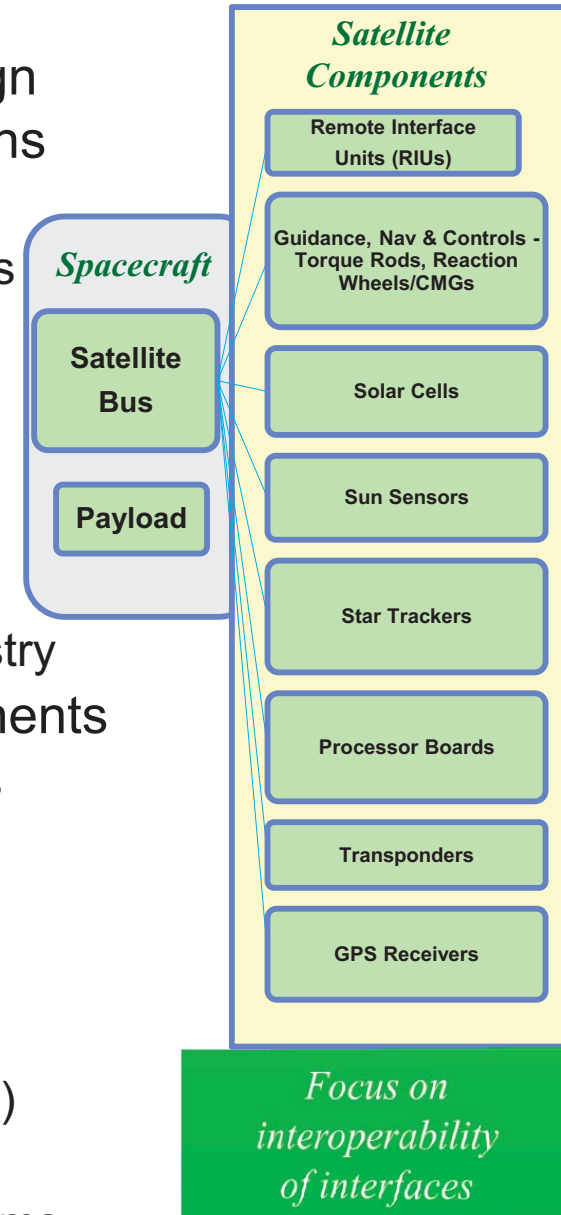
# Spacecraft Onboard Area Goals

✦ To define reference onboard communications architectures and services supporting efficient data  
2. ing applications and future system evolution, including:

- ✧ Standardized avionics architectures;
- ✧ Advanced technologies, such as wireless communications and software defined radios;
- ✧ Innovative approaches such as Plug-and-play approaches and Electronic Data Sheets.
- ✧ Onboard Autonomy Capabilities



- ✦ Interoperable spacecraft components from “bounding” design characteristics/features, test environments, and specifications
  - ✧ Standard electrical interfaces
  - ✧ Standard testing that applies LEO to GEO and Minotaur to Atlas
  - ✧ Benefits: cost savings, innovation & improvement, mission assurance and assembly time
- ✦ Modular architecture with plug & play (P&P)
  - ✧ High speed data bus; pin out and data definitions
- ✦ Leverages existing initiatives and standard development
  - ✧ Space Modular and P&P standards from ESA, NASA and industry
- ✦ Focus on satellite bus interface with sub-systems & components
  - ✧ Data & electrical interoperability; avoid defining mechanical I/Fs
  - ✧ Emphasize capabilities over requirements
  - ✧ Potential benefits for payload interoperability
  - ✧ Retain intellectual property and unique designs “inside the box”
- ✦ SUMO Standards Progress
  - ✧ Broad support achieved during CCSDS Fall Plenary (Cleveland)
  - ✧ Initially considered as a new CCSDS WG proposal
  - ✧ Now, Discussing how to integrate SUMO into existing SOIS teams



# Mission Ops & Info Mgt Area Goals

- ✦ To define the full suite of mission operations standard functions and services to enable ground and on-board interoperability at the application layer level in support of







Mission Ops &  
Info Mgt Services

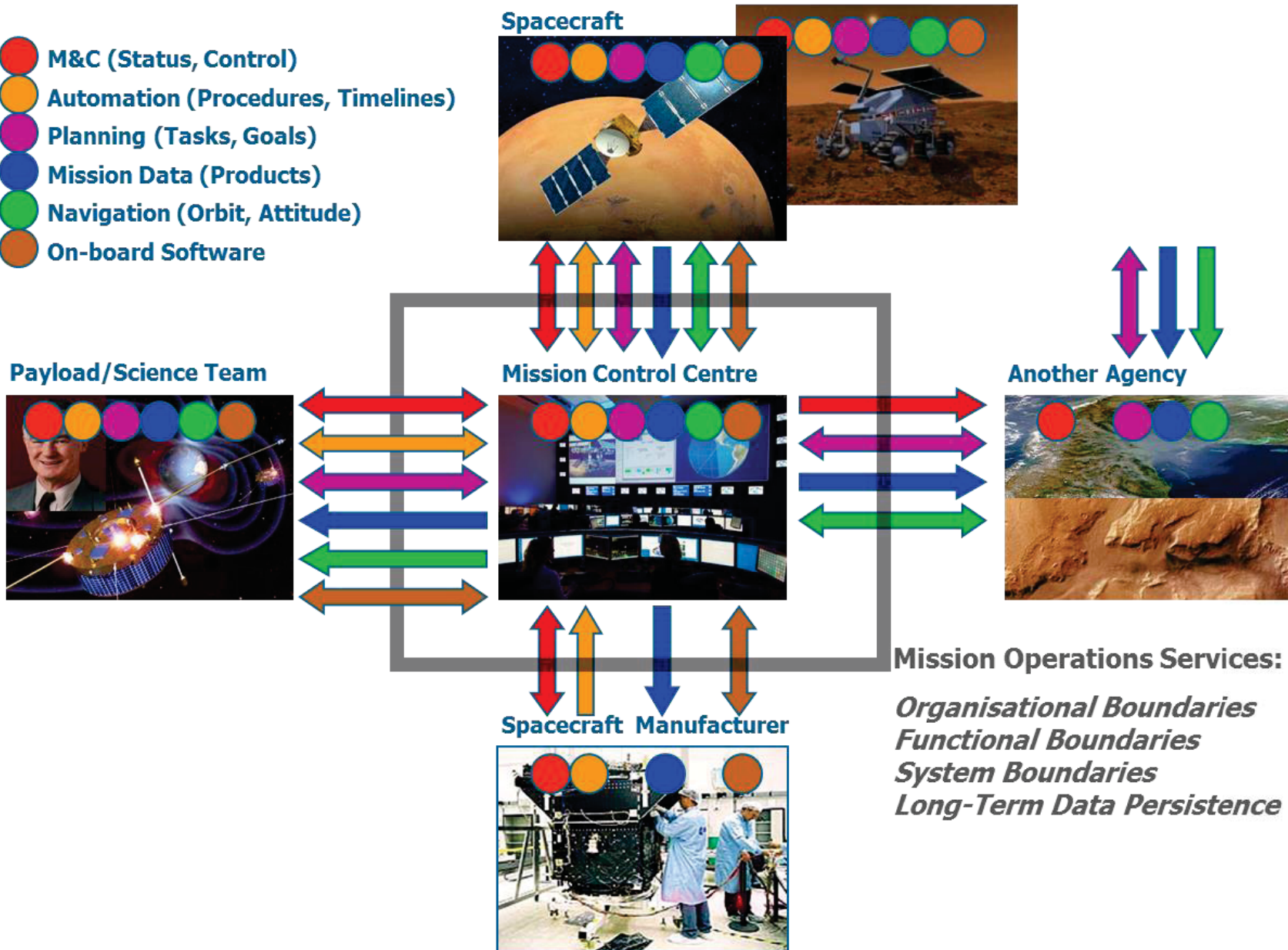
3.

standardization of the corresponding ground data systems, including:

- ✧ Implementation of multimission spacecraft and instrument Monitoring and Control systems;
- ✧ Exchange of mission plans between cooperating agencies;
- ✧ Conjunction assessment, navigation and trajectory prediction;
- ✧ Interoperability of robotic systems for cross-agency support.

# Distributable Mission Operations Functions

-  M&C (Status, Control)
-  Automation (Procedures, Timelines)
-  Planning (Tasks, Goals)
-  Mission Data (Products)
-  Navigation (Orbit, Attitude)
-  On-board Software



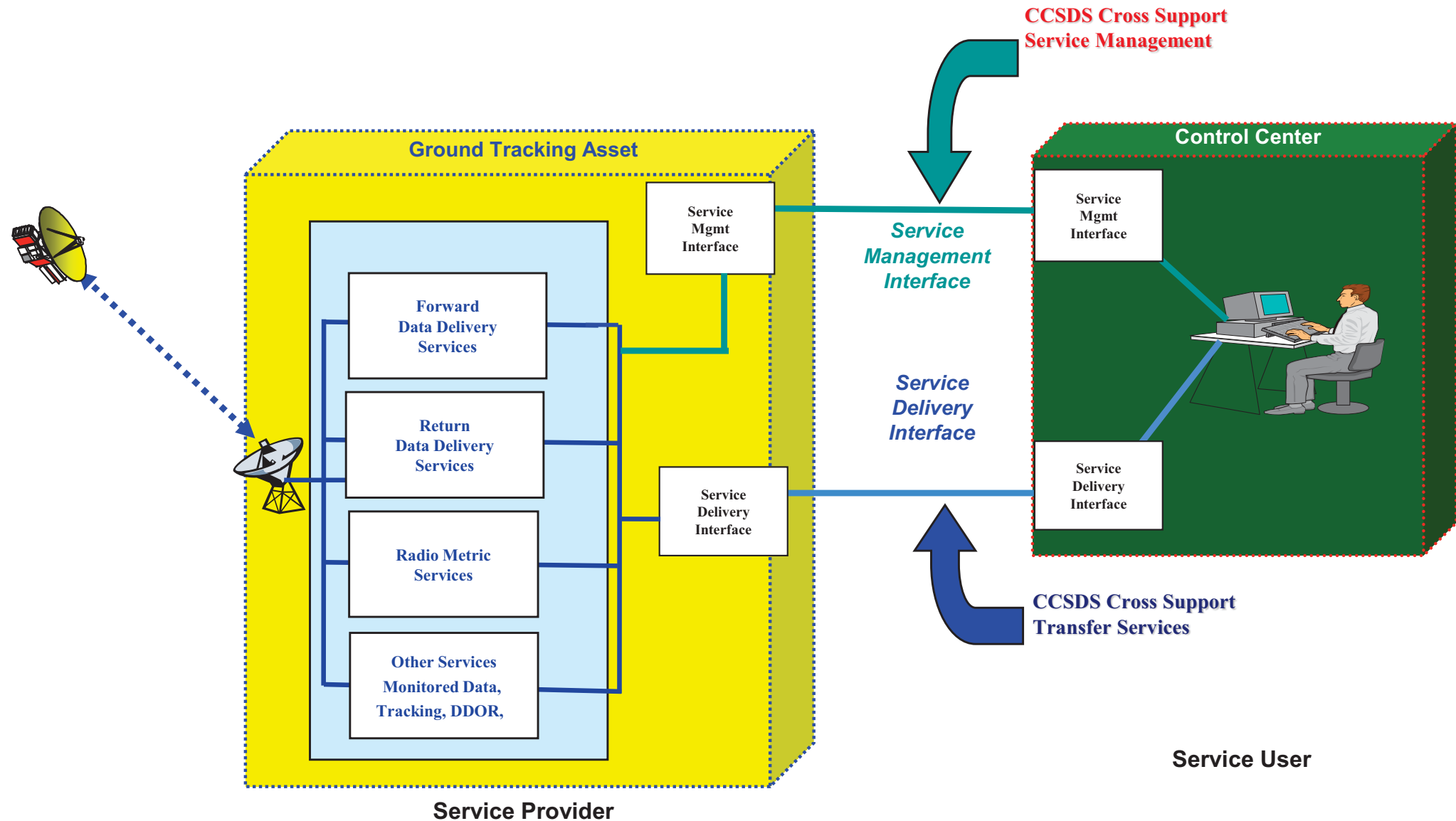
# Cross Support Services Area Goals

- ✦ To define a complete suite of interoperable, cross support planning, data delivery, and control service interfaces, implementing an efficient management of the cross support services, providing end to end solutions, and meeting mission challenges, including:
  - ✧ Integrated mission planning for combined interagency operations
  - ✧ Taking into account resource needs;
  - ✧ Simplification and improved efficiency of cross support service request, delivery and governance;
  - ✧ Call-up of international cross-support during spacecraft emergencies.
  - ✧ A complete suite of cross support interfaces supporting forward and return data transfers, radiometric data, monitor data and service control;
  - ✧ End-to-end file transfer operations

Cross Support  
Services

4.

# Framework for extensible Space Communications Cross Support Service

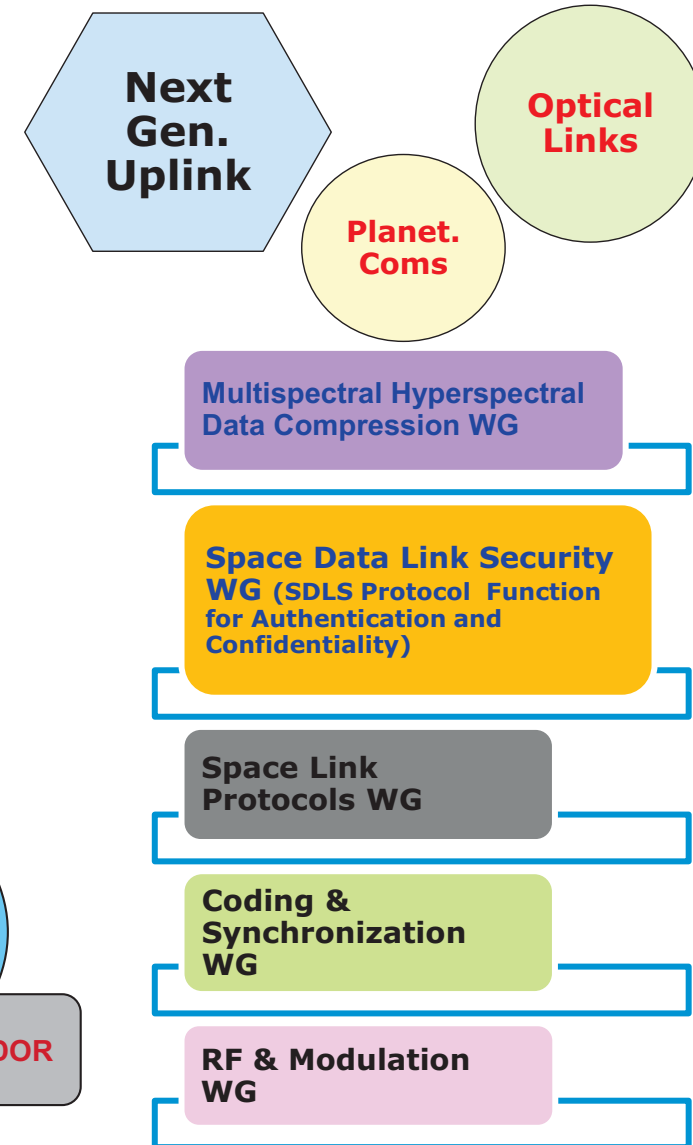
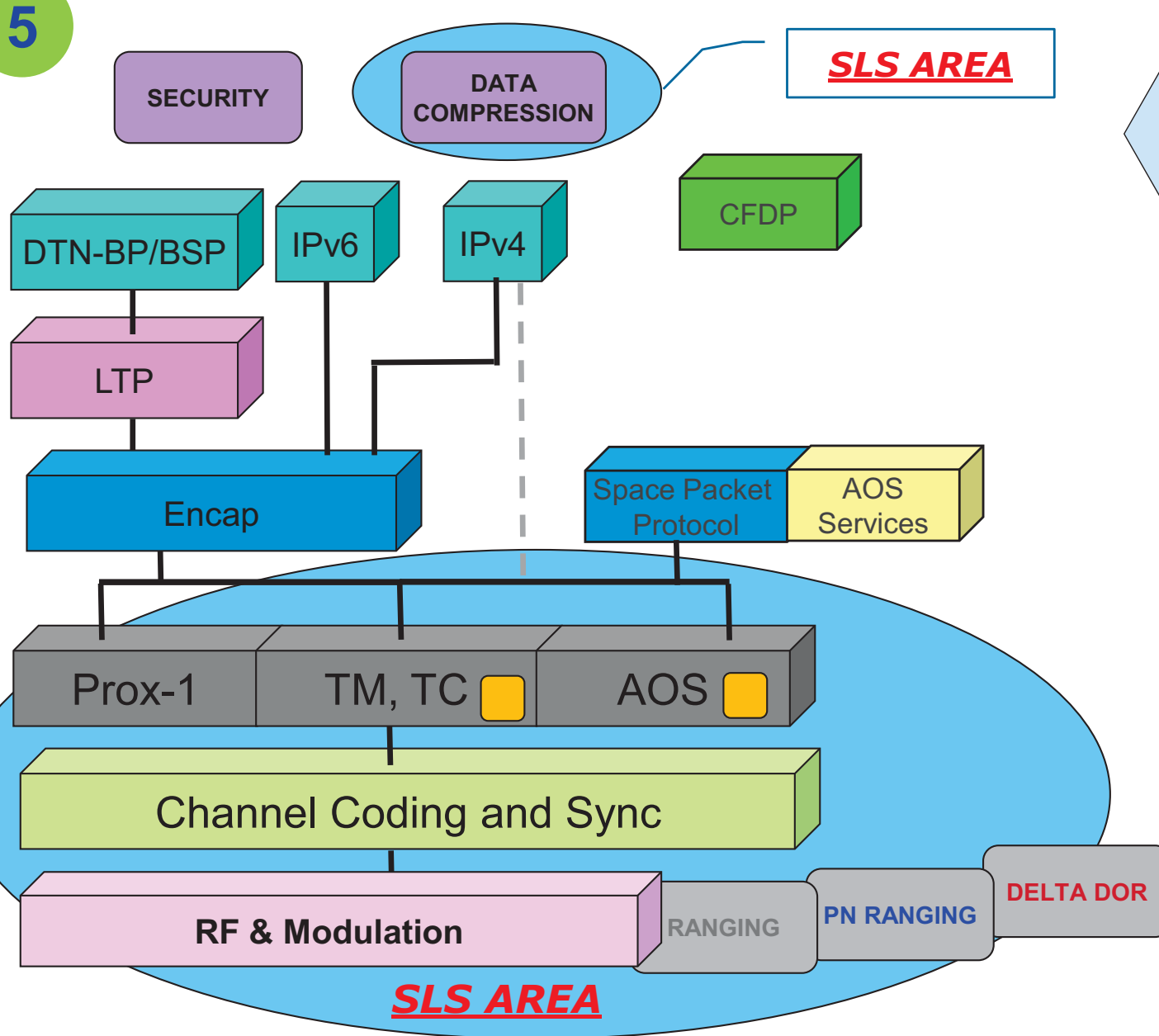




# Space Link Services Area Goals

- ✦ To define innovative, secure, widely applicable communication standards and related architectures that facilitate interoperability and cross support and meet the challenges and anticipated needs of the future projects, including:
  - ✧ Increased bandwidth capacity approaches (radio frequency and optical);
  - ✧ The achievement of higher information data rates and greater spectral efficiency
  - ✧ more capable protocols, modulation, coding and compression techniques;
  - ✧ Introduction of advanced physical and link layer communications technology providing significantly higher data return;
  - ✧ The use of secure communication protocols and links, to protect associated systems and information flows.

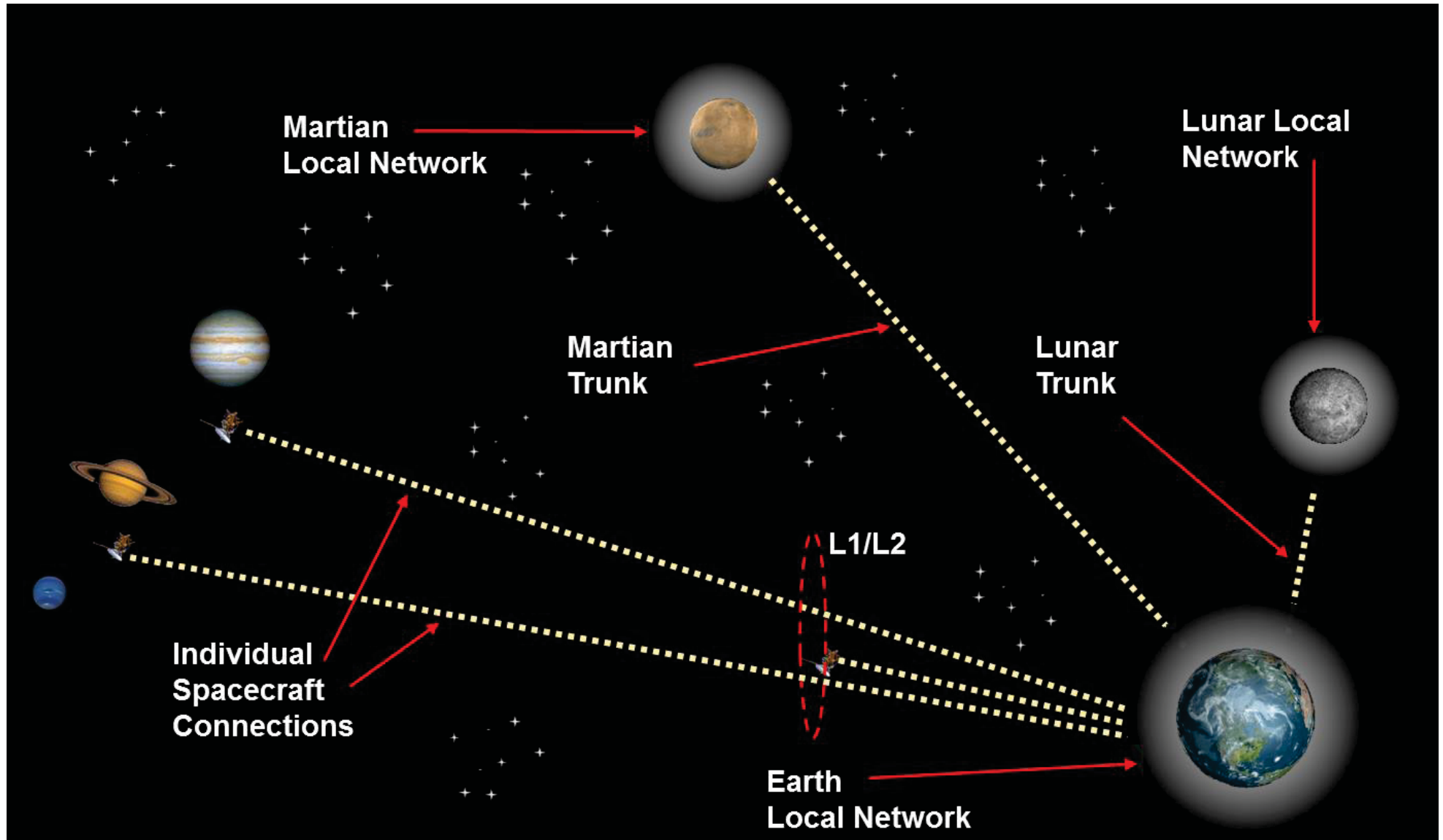
# Space Link Services Layered approach



# Space Internetworking Area Goals

- ✦ To define an integrated set of Space Internetworking standard services in support of end-to-end communications between applications covering the entire solar system and meeting future project needs, including:
  - ✧ Jointly conducted human and robotic operations;
  - ✧ Management of space-to-space and direct-to-earth links as part of the network;
  - ✧ Sensorweb and other innovative technologies for LEO operations;
  - ✧ Application to the space domain of well-established internetworking technologies.

# Top Level Comm/Nav Architecture The Solar System Internet



# **CLOSEUP on CCSDS Activities In Select Working Groups**



- ✦ The CCSDS Security Working Group:
  - ✧ Develops CCSDS security recommendations (standards)
  - ✧ Develops security guides and informative documents
  - ✧ Provides security advice and guidance to CCSDS working group for security factors and practices in other CCSDS standards.
- ✦ Documents developed:
  - ✧ Green Book on use of security in CCSDS
  - ✧ CCSDS Security Architecture
  - ✧ Algorithm trade studies for encryption and authentication
  - ✧ System interconnection guide
  - ✧ Threat guide
  - ✧ Key management guide and standard
  - ✧ Mission planner's security guide
- ✦ On-going work:
  - ✧ Encryption and authentication algorithm standard
  - ✧ CCSDS Encryption Algorithms (blue book)
  - ✧ Network layer security profile
  - ✧ Information security glossary

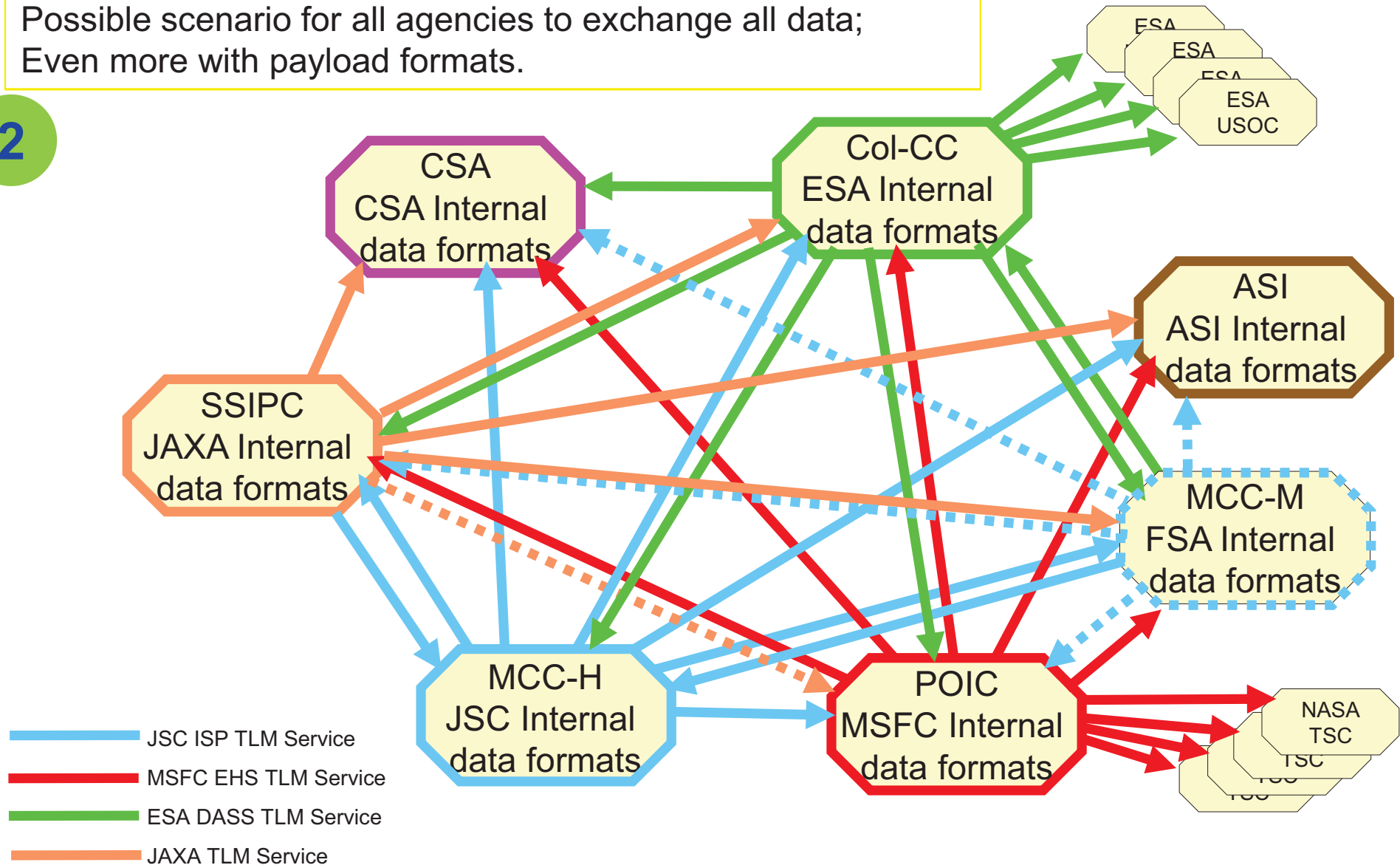
- ✦ Overview of Onboard Wireless activity
  - ✧ For basic spacecraft design, reduces launch mass of vehicles
  - ✧ For operations concepts, allows untethered mobility of crew and instruments
  - ✧ On the ground, potential utility for standards in test and integration
- ✦ Approved documents:
  - ✧ Green Book: *Wireless Network Communications Overview for Space Mission Operations*
    - ◆ Examines the possibilities and advantages of the application of *wireless communications technology* to space missions
  - ✧ Magenta Book: *RFID-Based Inventory Management Systems*
    - ◆ Improve ground system and spaceflight vehicle inventory tracking & visibility
  - ✧ Magenta Book: *Low Data-Rate Wireless Communications for Spacecraft Monitoring and Control*
    - ◆ targeted towards low data-rate and low-power applications transmitting in the 850 MHz – 950 MHz and 2.45 GHz (ISM) radio frequency band
- ✦ Future work:
  - ✧ High data rate wireless communications for space missions:
    - ◆ Focus is on high-rate wireless for voice, video, medical service provision.

- ✦ Emphasis is on standardizing service interfaces for common functions that are in every mission, at the ***application level***
  - ✧ Early emphasis is for ground-to-ground interfaces
  - ✧ Starting testing for flight systems interfaces as well
- ✦ Capitalizes on industry-accepted approach of a SOA (Service Oriented Architecture)
  - ✧ Standardizing interactions of providers and consumers of service
  - ✧ Includes discovery of services (auto-configuring interfaces)
  - ✧ Plug-n-play characteristics: Finally allowing operational/management decisions to be independent of software development projects
  - ✧ Provides application portability as well as interoperability
- ✦ Progress to date:
  - ✧ Basic framework (Message Abstraction Layer, etc.) is published.
  - ✧ First applications (Telemetry, Command, common services) published
  - ✧ Alerts (alarm limits, etc.) currently in review cycle
  - ✧ Some future work will be spin-offs (Telerobotics, Planning, etc.)
- ✦ New Development: IOAG committee considering oversight of MO Services (note – SM&C protocols and MO Services are equivalent)

# Mission Ops TLM Services ISS Current formats

Possible scenario for all agencies to exchange all data;  
Even more with payload formats.

2

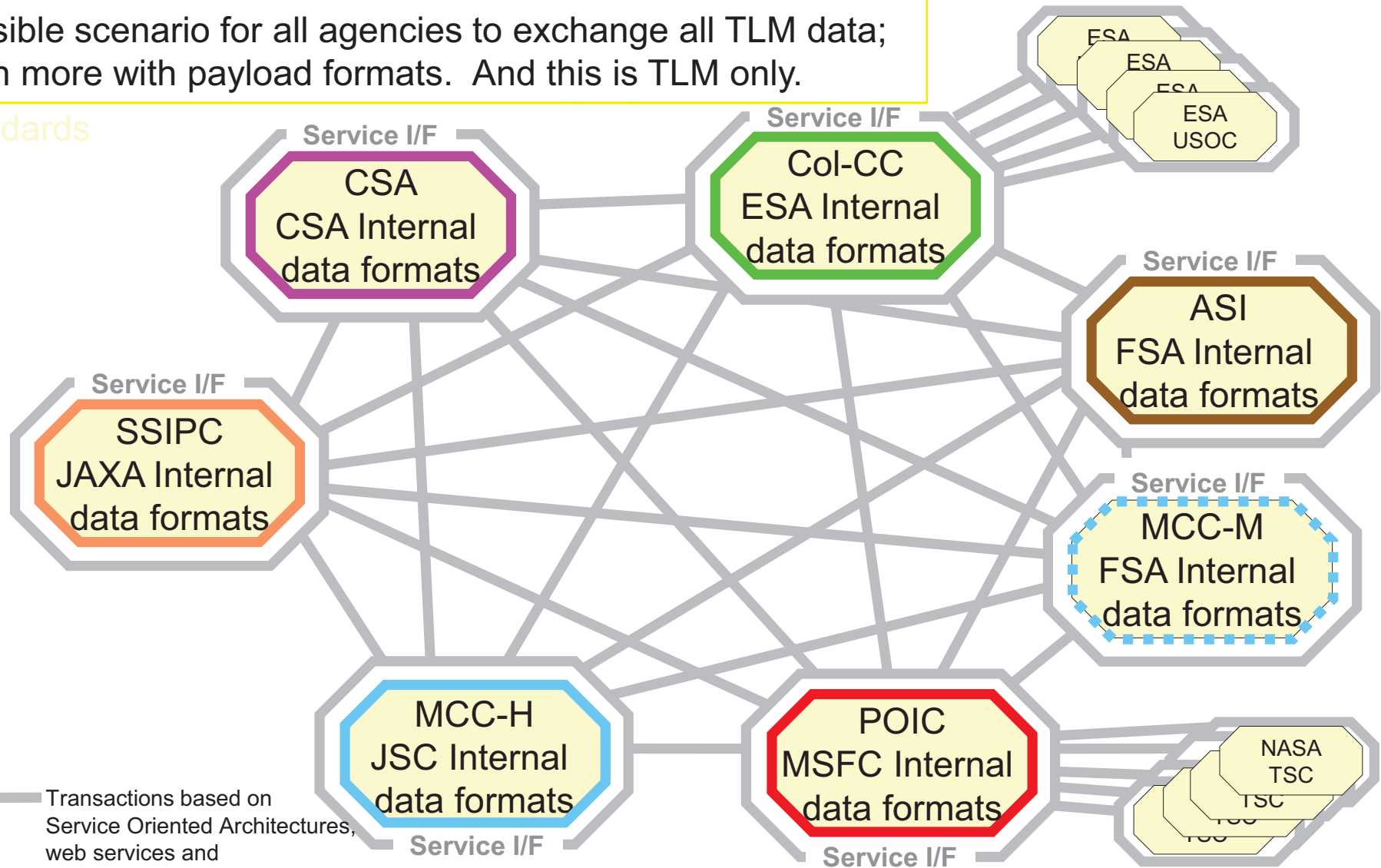


# Mission Ops TLM Services Future Harmony

Possible scenario for all agencies to exchange all TLM data;  
Even more with payload formats. And this is TLM only.

2

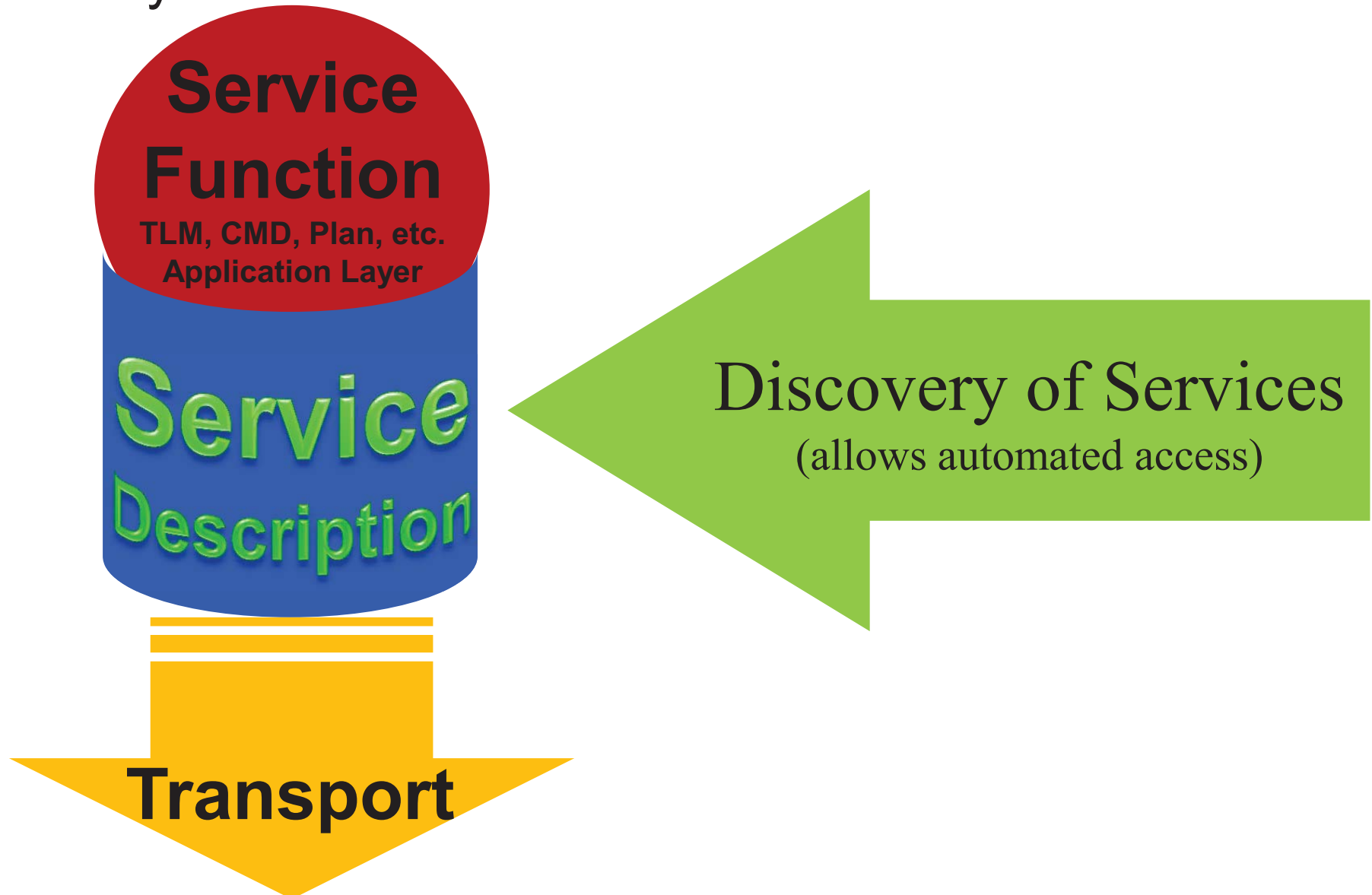
Standards



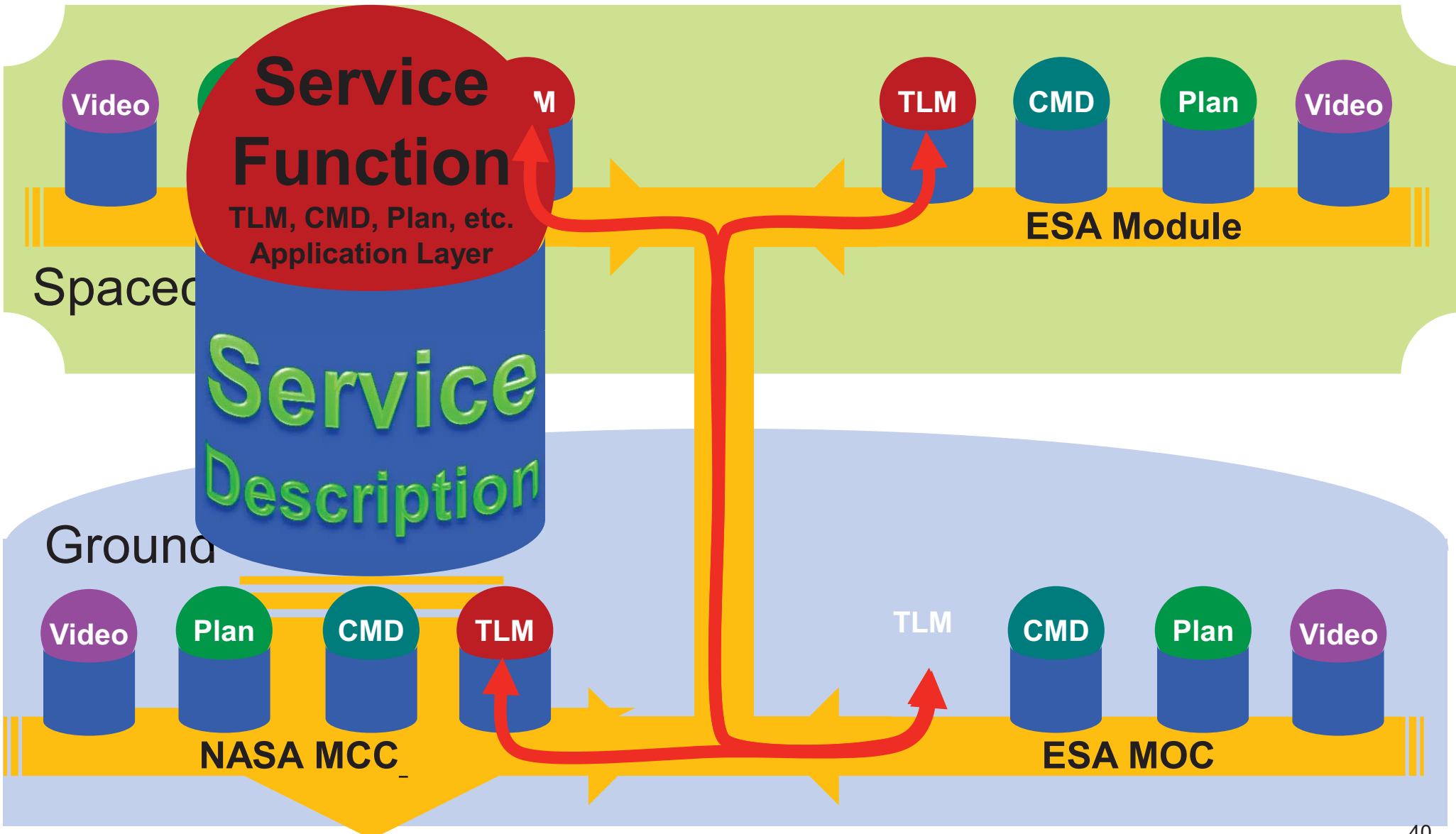
Transactions based on  
Service Oriented Architectures,  
web services and  
service interfaces



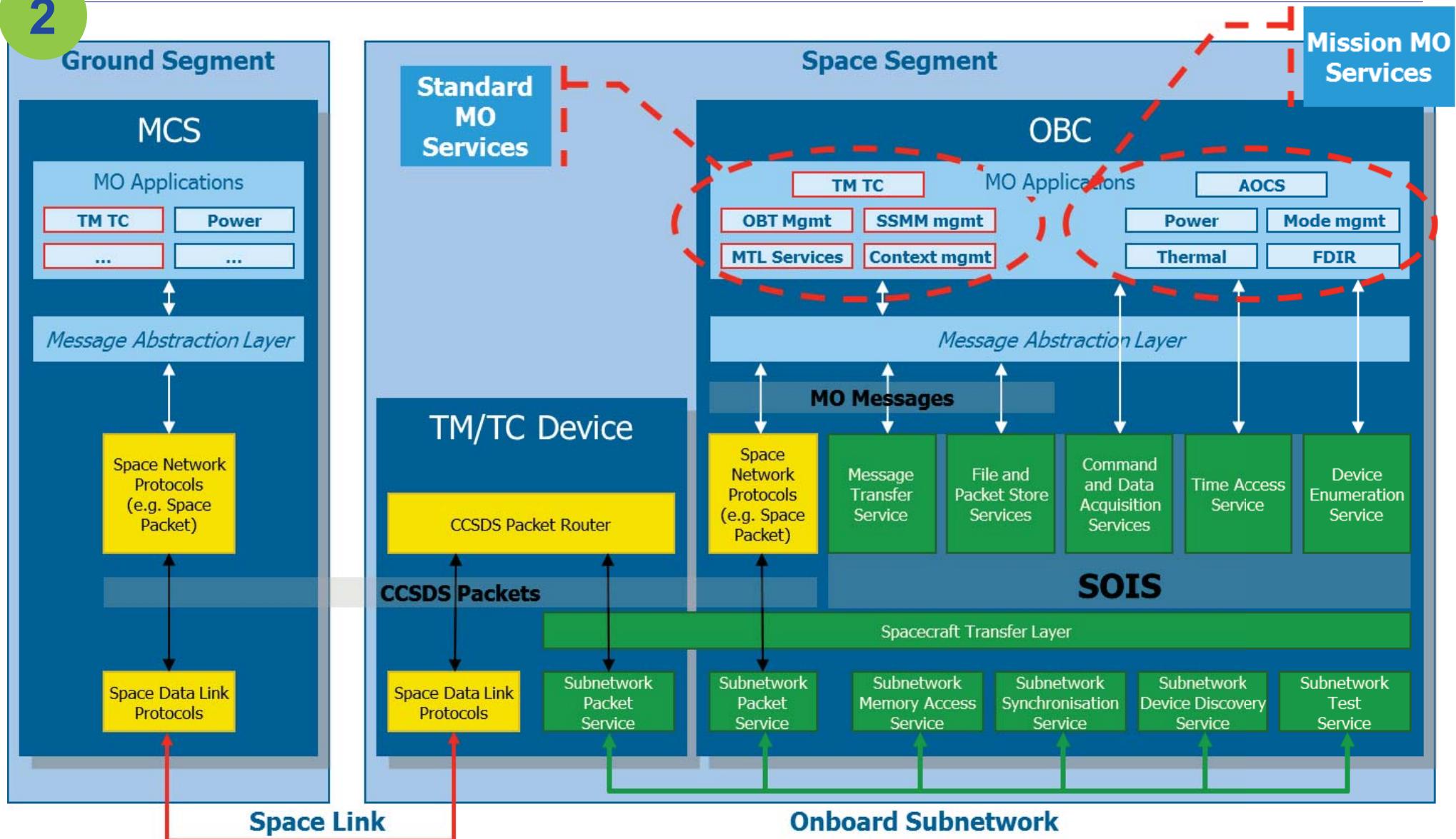
Service Oriented Architecture  
→ widely used in other industries



Cross-support is based on operational configuration and on security  
→ NOT on a new software development project.



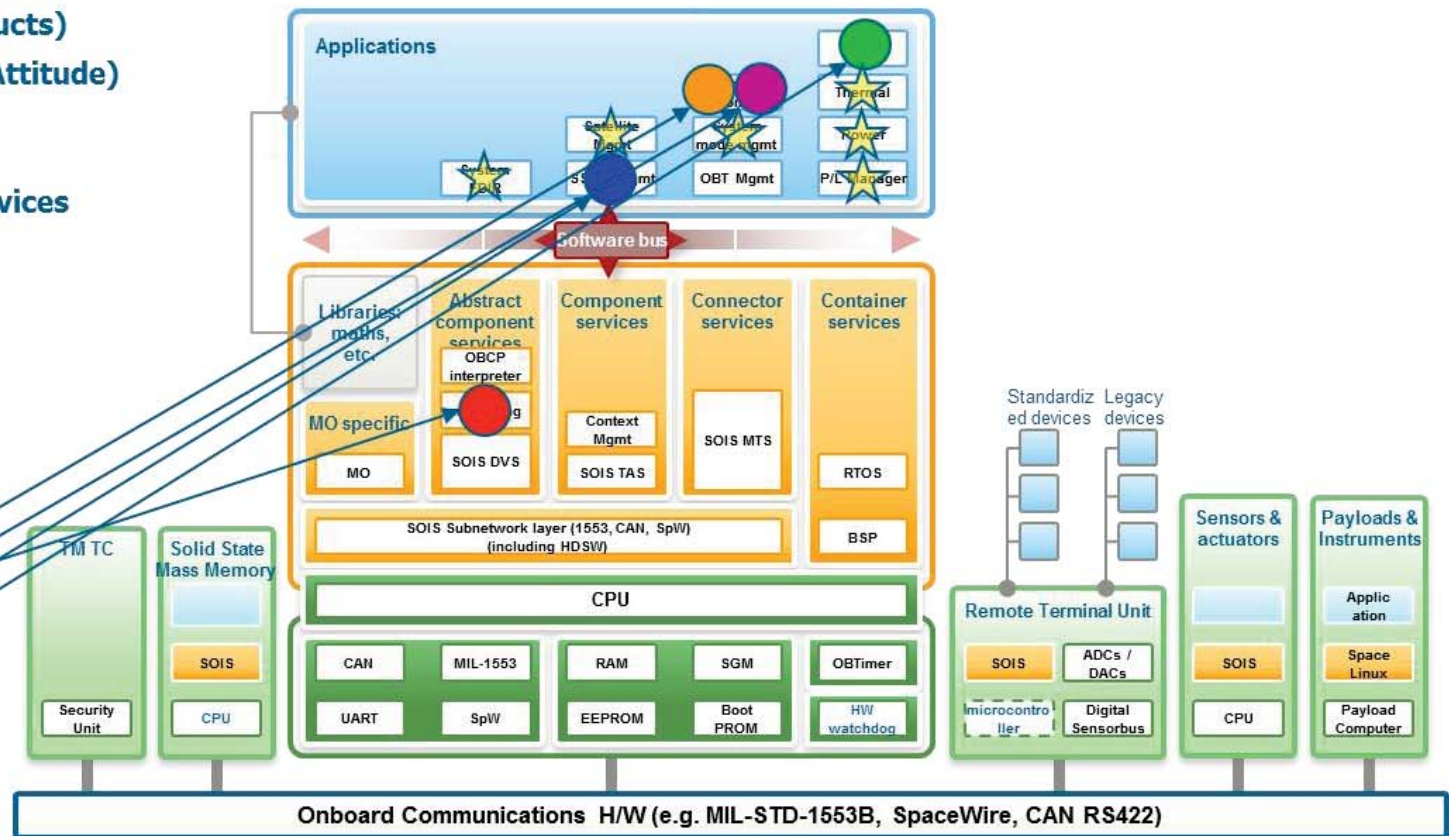
# Future architecture



# Distributable Mission Operations Functions

2

- M&C (Status, Control)
- Automation (Procedures, Timelines)
- Planning (Tasks, Goals)
- Mission Data (Products)
- Navigation (Orbit, Attitude)
- On-board Software
- ★ Mission specific services





- ★ The CCSDS Navigation Working Group is chartered to develop standards covering exchange of spaceflight dynamics related data
- ★ Past Progress and Current Work
  - ✧ Orbit Data Messages (version 2.0 published 11/2009)
    - ◆ Three standard message formats for exchanging orbit descriptions
  - ✧ Tracking Data Message (version 1.0 published 11/2007)
    - ◆ Message format for exchanging tracking data; supports widely used tracking data types: Doppler, range, angle,  $\Delta$ DOR, ancillary information
  - ✧ Attitude Data Messages (version 1.0 published 05/2008)
    - ◆ Two message formats for exchanging spacecraft attitude descriptions
  - ✧ Navigation Green Book (version 3.0 published 05/2010)
    - ◆ Contains technical background related to the Nav WG Recommendations
  - ✧ Nav Data Messages XML Specification (version 1.0 published 12/2010)
    - ◆ Contains XML representations of all above Nav WG standards
  - ✧ Conjunction Data Message (pub June 2013)
    - ◆ Standard message format for informing spacecraft operators of object conjunctions in space (spacecraft/spacecraft, spacecraft/debris, debris/debris)
- ★ Future work
  - ✧ Pointing Requests Message – communicating complex on-orbit cross-support pointing requests (e.g., inertial, limb, terminator, velocity, nadir, track)
  - ✧ Navigation Hardware Message – exchanging onboard navigation H/W data between space agencies (e.g., thrusters, accelerometers, star trackers, etc.)
  - ✧ Spacecraft Maneuver Message – exchanging information regarding spacecraft maneuvers (requirements, design, reconstructed performance)



# The Navigation Roadmap

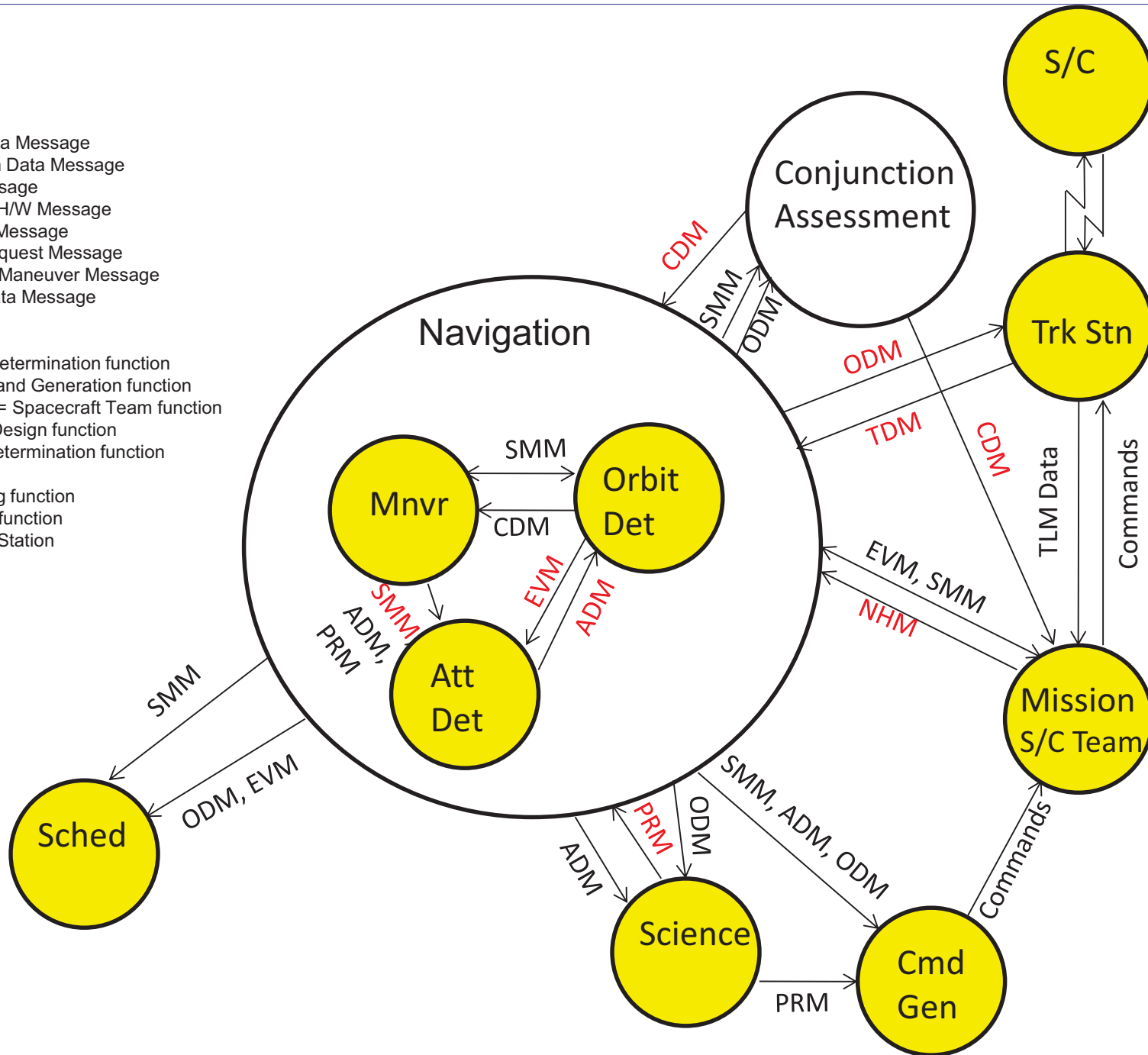
3

## Messages

**ADM** = Attitude Data Message  
**CDM** = Conjunction Data Message  
**EVM** = Events Message  
**NHM** = Navigation H/W Message  
**ODM** = Orbit Data Message  
**PRM** = Pointing Request Message  
**SMM** = Spacecraft Maneuver Message  
**TDM** = Tracking Data Message

## Functions

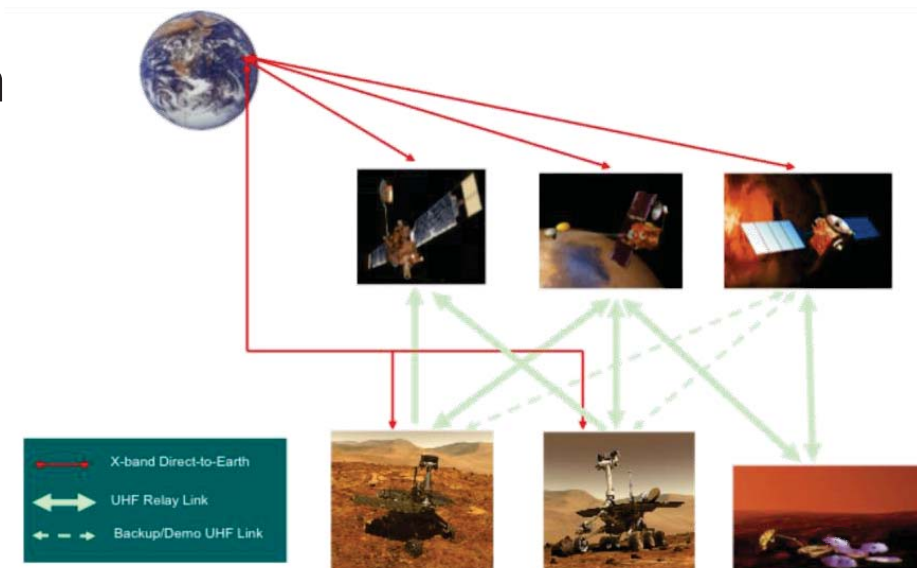
Att Det = Attitude Determination function  
Cmd Gen = Command Generation function  
Mission S/C Team = Spacecraft Team function  
Mnvr = Maneuver Design function  
Orbit Det = Orbit Determination function  
S/C = Spacecraft  
Sched = Scheduling function  
Science = Science function  
Trk Stn = Tracking Station

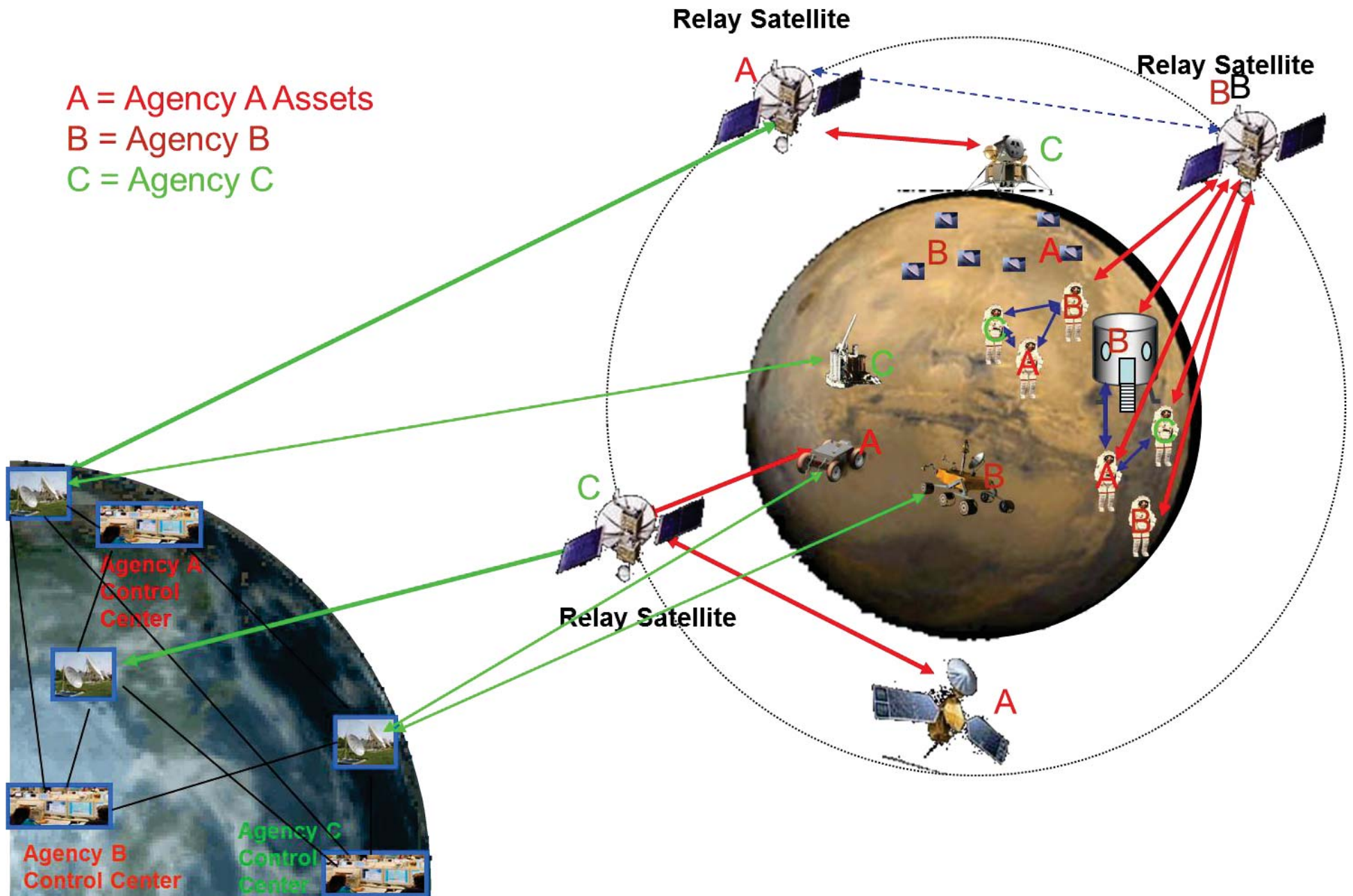


- ✦ Optical Coding and Modulation SIG (Special Interest Group)
  - ✧ Considering whether it is time for an Optical Comm standard
  - ✧ Would support Mars-Earth, LEO-GEO, LEO DTE scenarios
  - ✧ Interesting work in optical coding and modulation for interoperability

# Delay/Disruption Tolerant Networking (DTN)

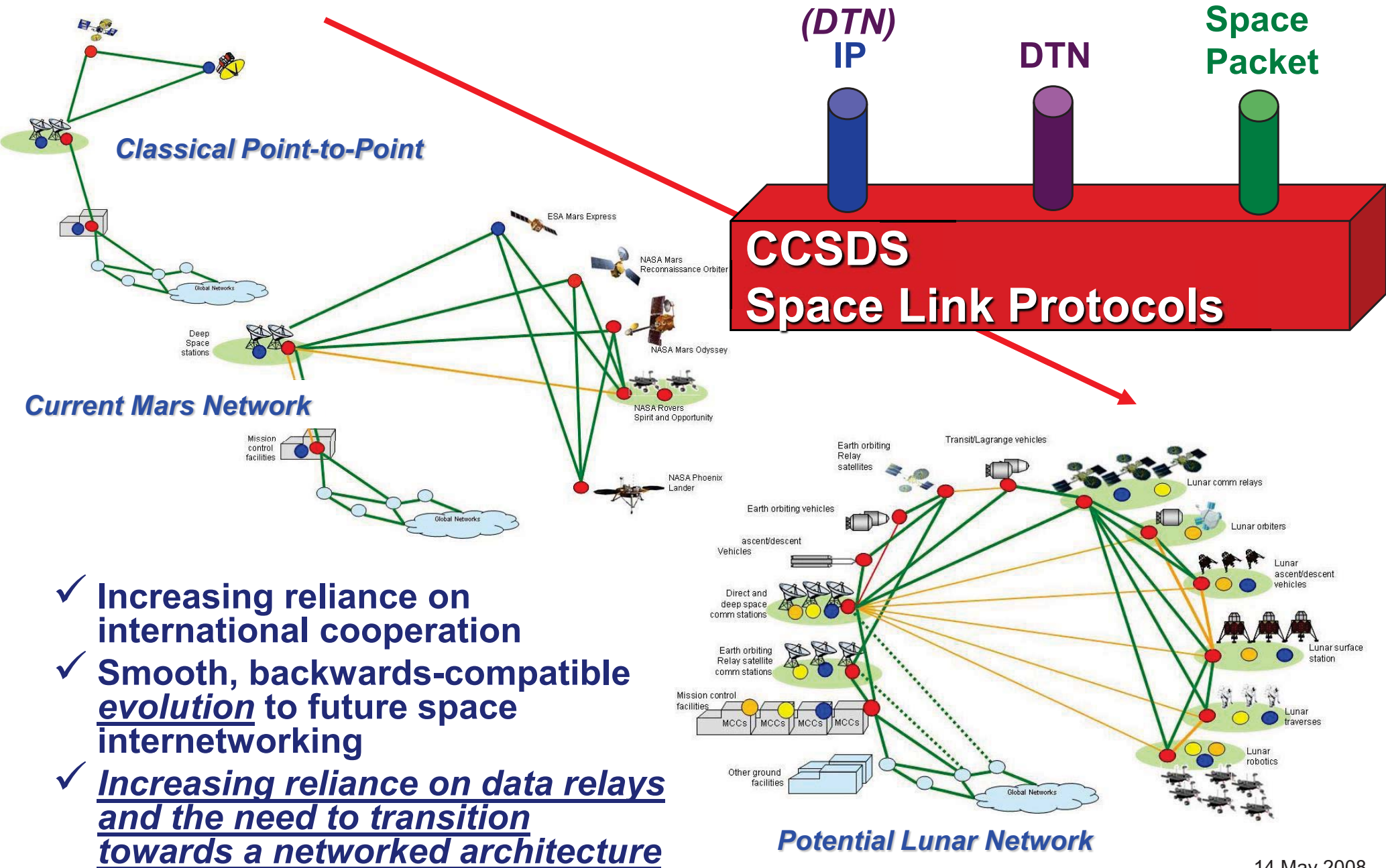
- ✦ The DTN Working Group is laying the foundation for the Solar System Internet (SSI)
  - ✧ Provides automated routing in space (like terrestrial Internet), but compared to current IP technology:
    - ◆ Adds Delay/Disruption tolerance for deep space environment
    - ◆ Delivers more data, faster in disrupted near-earth environment
- ✦ Past Progress and Current Work
  - ✧ Green book establishes rationale, develops scenarios, explores candidate technologies
  - ✧ Due to be approved/published this year: SSI Architecture Document, DTN Bundle Protocol (BP) specification and Licklider Transmission Protocol (LTP) Blue Books.
- ✦ Future work – Complete Solar System Internet (SSI) infrastructure with
  - ✧ Network Management
  - ✧ Contact Graph Routing
  - ✧ File Delivery Protocol (CFDP)







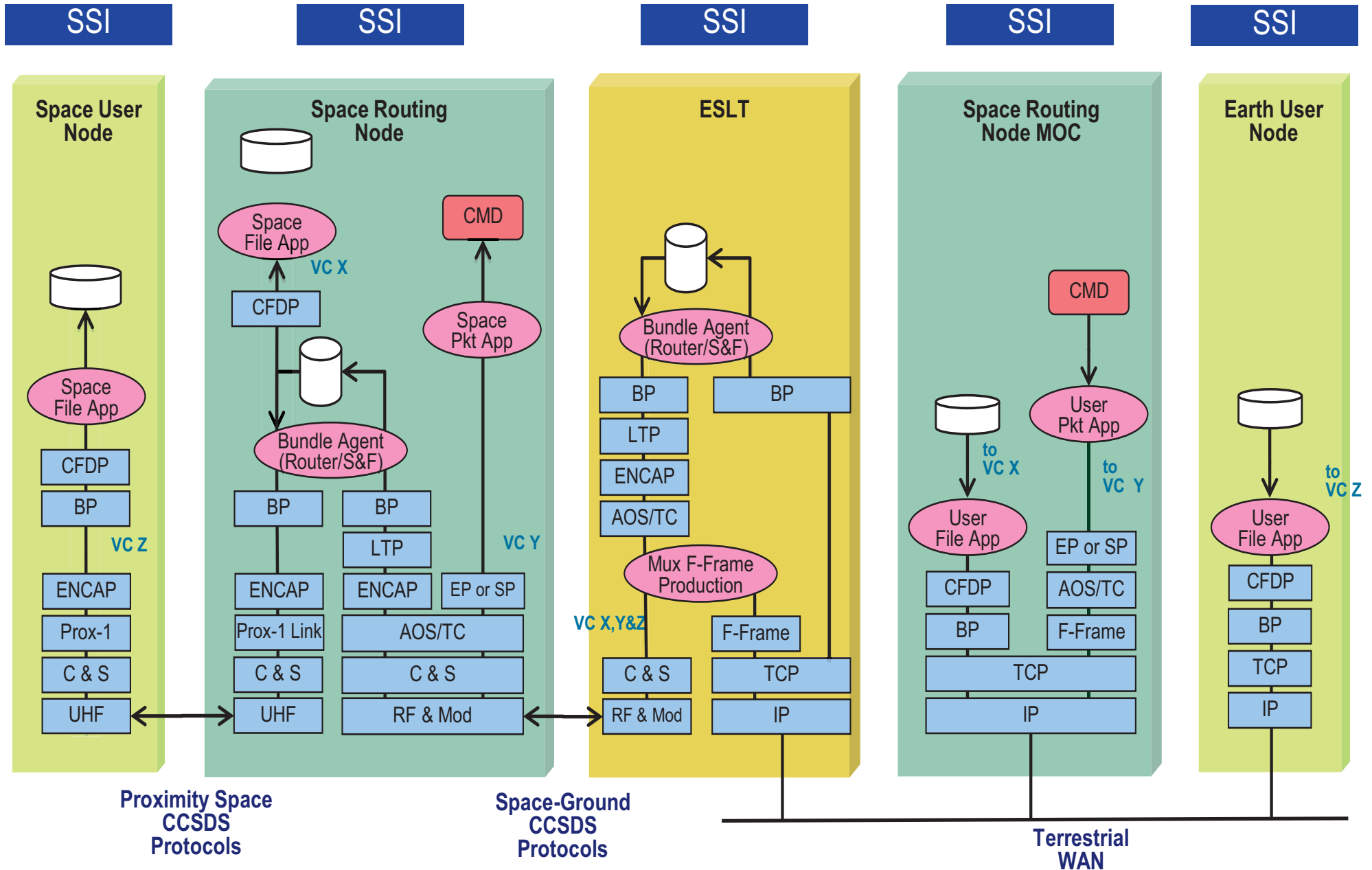
# A clear way forward to a networked architecture



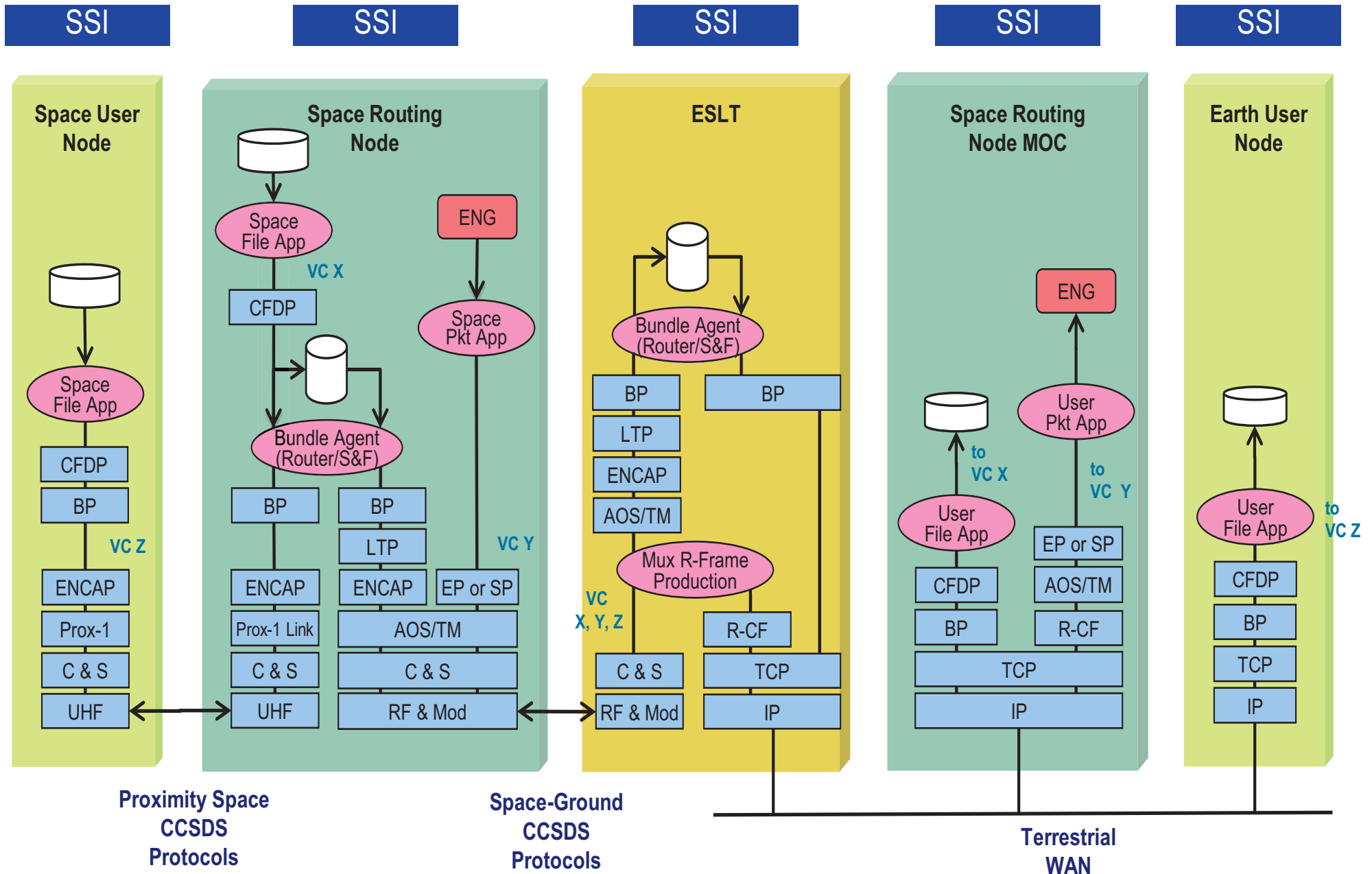


Interface between MOCs is streaming, not file-based, for DTN-enabled user





# SSI End-to-End Return All DTN



- ✦ The AMS Working Group ***FINISHED AND CLOSED***
- ✦ Completed standardizing messaging middleware for flight mission communications.
  - ✧ AMS provides “message bus” functionality for flight missions, including both publish/subscribe and client/server interaction models.
  - ✧ Unlike JMS or DDS, AMS is *a wire protocol rather than a service spec*
    - ◆ Conformant implementations are interoperable, no gateways needed.
  - ✧ Unlike AMQP, AMS is *peer-to-peer, not reliant on a message broker*
    - ◆ High performance, fault tolerant.
  - ✧ Unlike RTPS, AMS is *designed to run efficiently over space links*
    - ◆ Uses a built-in delay-tolerant and disruption-tolerant multicast tree.
- ✦ Overall benefit: Flight-system capable, loosely-coupled, simplified interfaces
  - ✧ Overall reduction in interface complexity
- ✦ Completed publication of Blue Book, and closed Working Group
- ✦ Reference implementation is available as open source, included in JPL’s “ION” software distribution at:  
<http://www.openchannelfoundation.org/projects/ION/>

## ★ Voice and Video WGs

- ✧ Classic problem of Voice/Video degradation from analog/digital conversions during cross support
- ✧ Digital video adds more complexity
- ✧ Plan to establish “profiles” of cross-supported commercial standards
- ✧ Addressing both ground systems (between MCC’s) and flight systems interoperability



## ✦ Telerobotics WG

- ✧ Seeking to develop standardized protocols for operating space-borne robotic systems

## ✦ Planning Systems (Future BOF)

- ✧ Seeking to develop standardized interfaces for exchange of Mission Operations Planning Data, for both robotic and human spaceflight programs.

# CCSDS Summary

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- ✦ Take-home message: Still much work to be done
  - ✧ Enabling interoperability between international agencies for future missions – both Earth-Orbital and Exploration
  - ✧ Long-range vision – automated routing and delay tolerant networking for deep space crosslinks between spacecraft and surface systems
  - ✧ Near-term need – evolutionary approach to sustain cross-support agreements with other agencies.
- ✦ Organizations with a stake in the future of Space Missions and the expertise to contribute to CCSDS should become engaged.

# **Other Opportunities for NSPO to participate in international activities**

- ✦ SpaceOps Committee organizes the SpaceOps Conferences every two years
  - ✧ Also other publication and outreach functions
- ✦ Valuable forum for exchanging info on the most important phase of a spaceflight mission: Operations!
- ✦ The next SpaceOps Conferences:
  - ✧ Pasadena California (JPL), May 2014
  - ✧ Daejeon Korea (KARI) May 2016
- ✦ Also, participation in the committee may be of interest to NSPO
  - ✧ Committee meets about twice per year
- ✦ [www.SpaceOps.org](http://www.SpaceOps.org).

# Space Generation Advisory Council

- ✦ SGAC is a non-profit organization that represents 18-35 year olds in international space policy at the United Nations, at agencies, in industry, and in academia
  - ◆ Founded as a result of the 1999 UNISPACE III conference
  - ◆ SGAC has had permanent observer status in the UN COPUOS since 2001 and has been a member of the UN Economic and Social Council since 2003
  - ◆ Is headquartered in Vienna, Austria and is hosted by the European Space Policy Institute
  - ◆ SGAC has a volunteer network of more than 4,000 members in over 100 countries
- ✦ Conferences
  - ◆ Space Generation Congress (SGC)
  - ◆ Space Generation Fusion Forum
- ✦ Year-round Projects
- ✦ Pragmatic Policy Suggestions
  - ◆ Reports to United Nations COPUOS committee
  - ◆ Recommendations from Space Generation Congresses
- ✦ Scholarships
- ✦ Special Projects
  - ◆ ISECG-NASA Videos, IAA Study Groups, European Space Expo, etc.





- ✦ The IOAG maintains a listing of communications ground stations that are available for international cross-support.
- ✦ NSPO sites are not currently included
- ✦ If NSPO has antenna sites that might be available to other agencies or organizations, to cross-support other programs, NSPO should submit the appropriate technical info to the IOAG.
- ✦ This allows mission planners in other agencies to know what is available.
- ✦ It may also be of interest to NSPO planners to see what comm resources are available to support your missions.
- ✦ Of course, cross-support with other agencies is achieved only through other negotiations for bilateral support.
- ✦ If NSPO is interested, contact Angel Oria at [angel.oria-1@nasa.gov](mailto:angel.oria-1@nasa.gov),
- ✦ Also CC the IOAG chairman Michael Schmidt ([Michael.Schmidt@esa.int](mailto:Michael.Schmidt@esa.int)) and IOAG secretariat, Stephanie Wan ([Stephanie.Wan@nasa.gov](mailto:Stephanie.Wan@nasa.gov)).

# CCSDS SLE and CSS

## Space Link Extension Cross Support Services

**Mike Kearney**

CCSDS Chair & General Secretary

NASA MSFC EO-01

256-544-2029

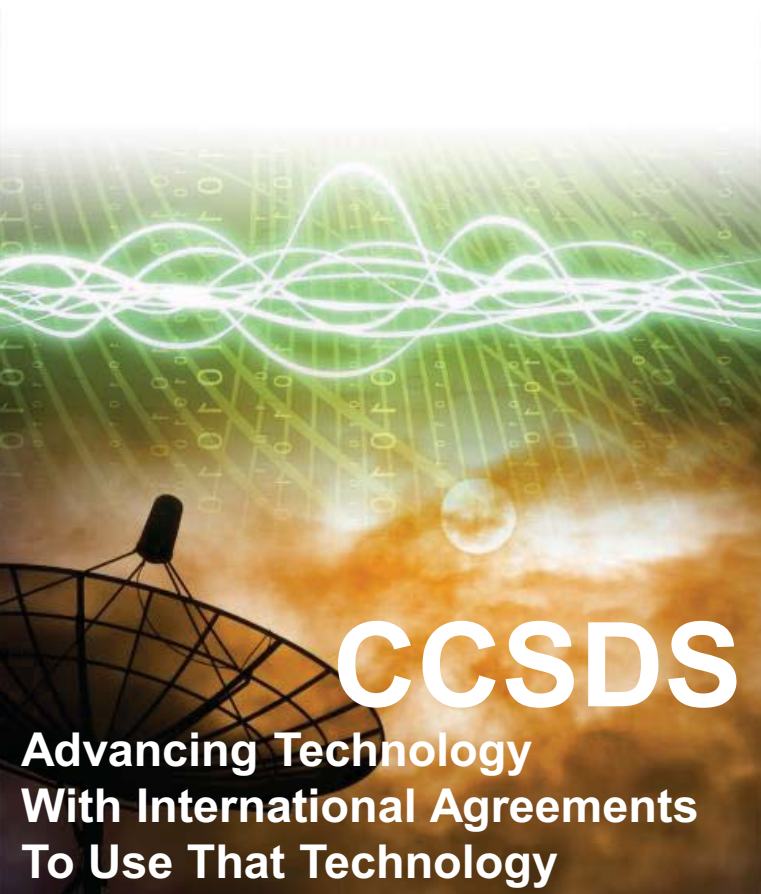
[Mike.Kearney@nasa.gov](mailto:Mike.Kearney@nasa.gov)

**Erik Barkley**

Cross Support Services Area Director

NASA JPL 3970

[Erik.J.Barkley@jpl.nasa.gov](mailto:Erik.J.Barkley@jpl.nasa.gov)



# Agenda

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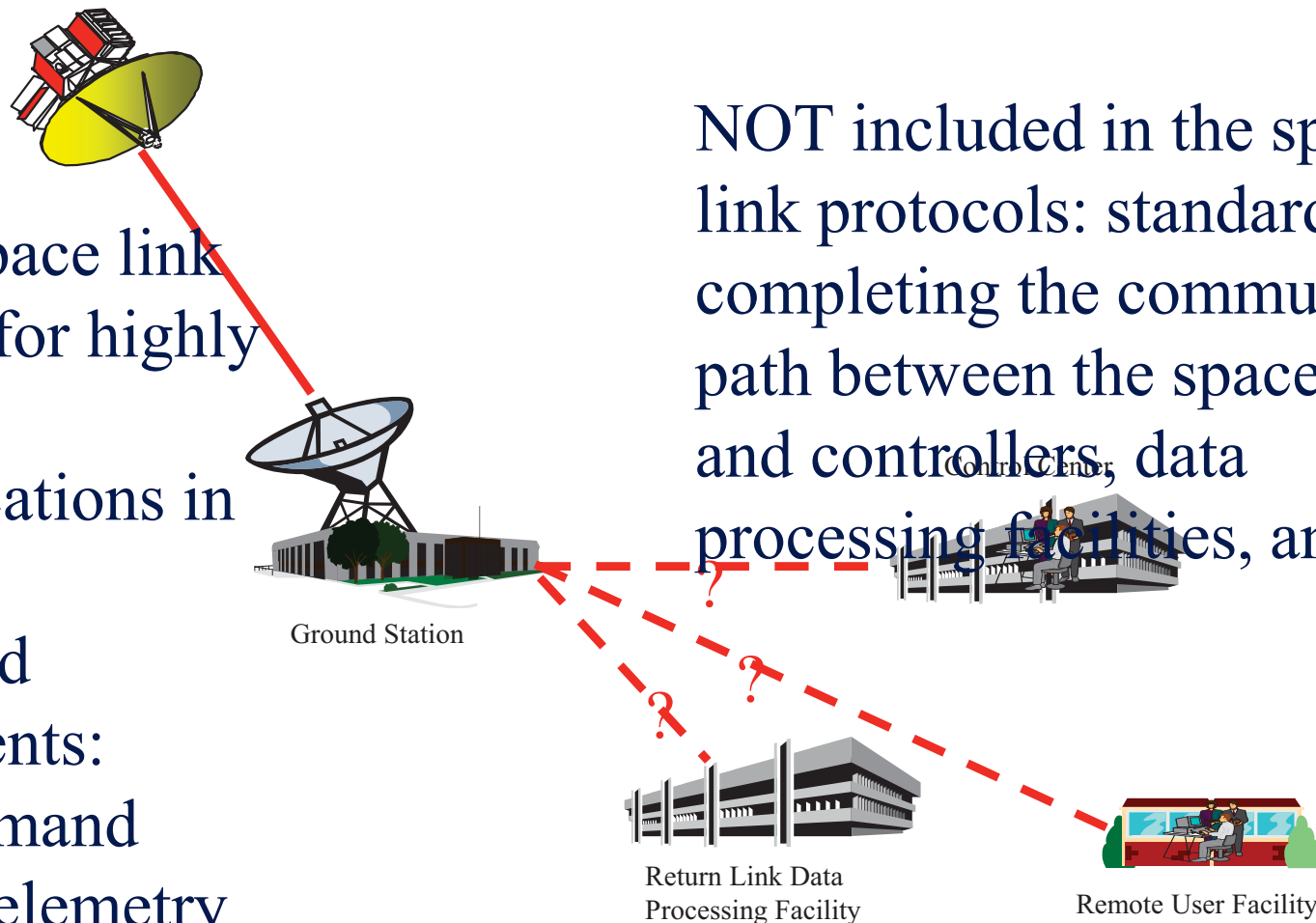
- ✦ Space Link Extension (SLE)
- ✦ Transition from SLE to CSTS
- ✦ Cross Support Transfer Services (CSTS)
- ✦ Cross Support Service Management (CSSM)
- ✦ Cross Support Area Projects
- ✦ Conclusions

# The Situation circa 1990

## (State of CCSDS Standardization of S/C Communications)

CCSDS space link  
Protocols for highly  
efficient  
communications in  
resource-  
constrained  
environments:

- Telecommand
- Packet Telemetry
- Advanced Orbiting



NOT included in the space  
link protocols: standards for  
completing the communication  
path between the spacecraft  
and controllers, data  
processing facilities, and users

# The Situation Circa 1990: Agency Specific Solutions

Spaceflight missions “roll their own” ground services to transfer CCSDS

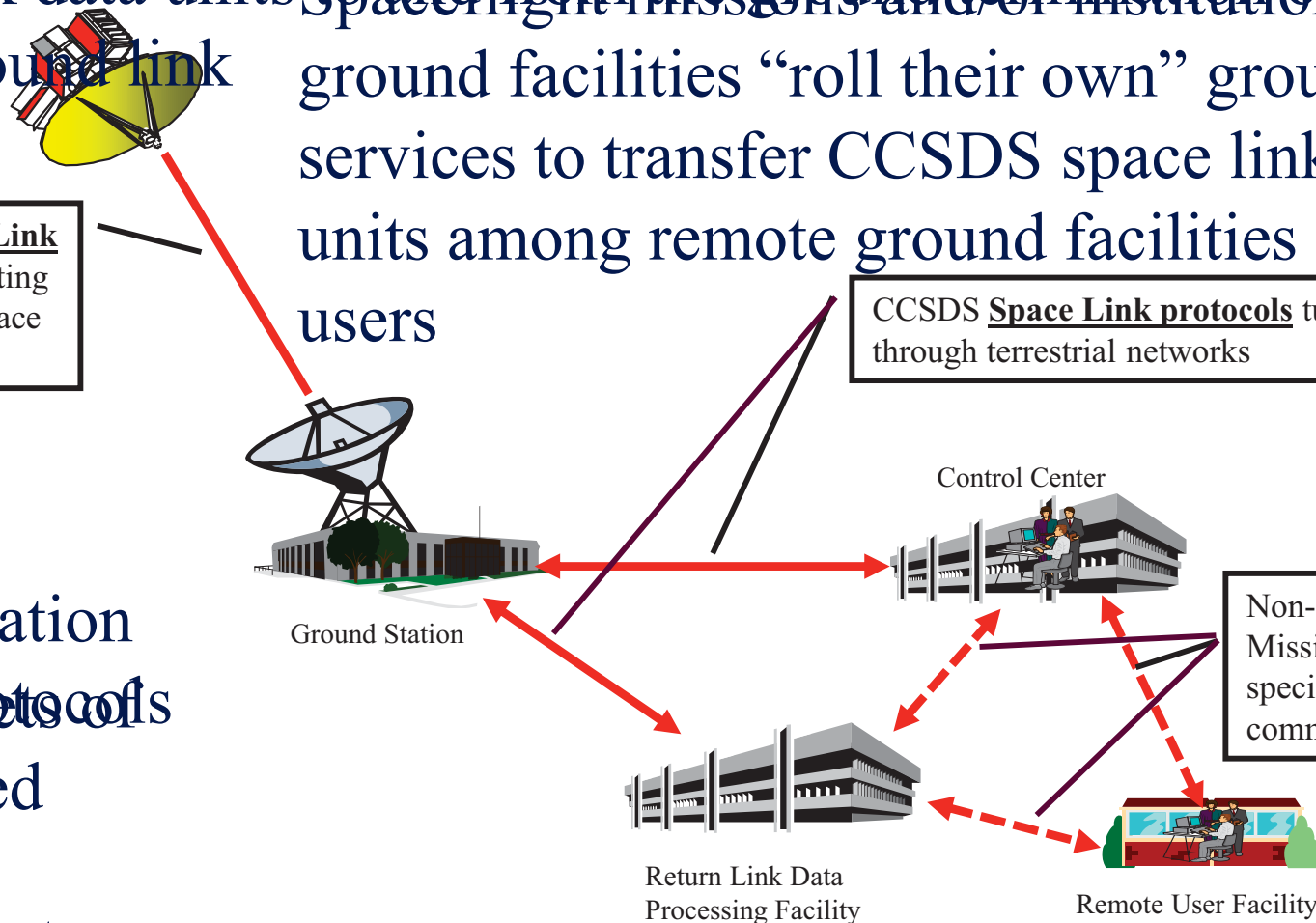
space link data units to and from the ground and termination of the space-ground link

Spaceflight missions and/or institutional ground facilities “roll their own” ground services to transfer CCSDS space link data units among remote ground facilities and users

CCSDS Space Link protocols operating natively over space link

CCSDS Space Link protocols tunneled through terrestrial networks

Multiple communication protocols  
Multiple protocols  
value-added features  
Multiple management capabilities and





# The Situation from 2001 to present

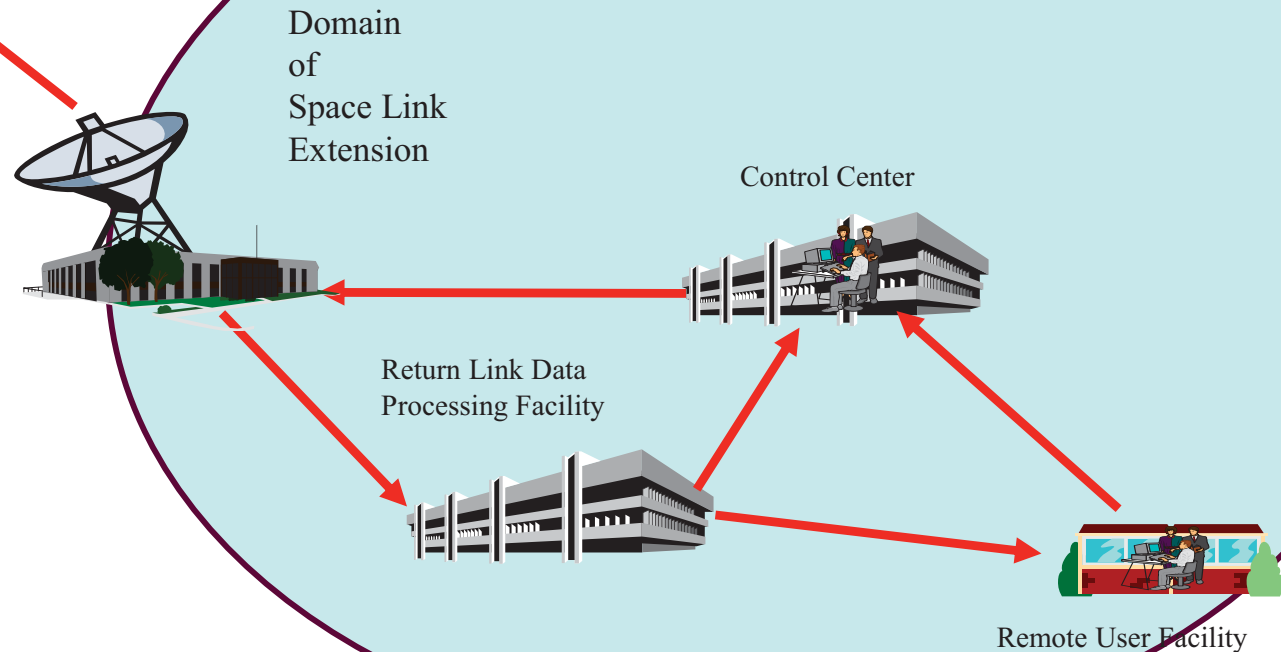
## Space Link Extension

Standard services for exchanging CCSDS space link data units between ground termination of the space link and remote users

Standardizing terrestrial links as well as space links

Evolution of mission-unique/provider-unique services

Only requires that CCSDS link protocols be used on the space-ground link



# Standardized Capabilities of SLE Services

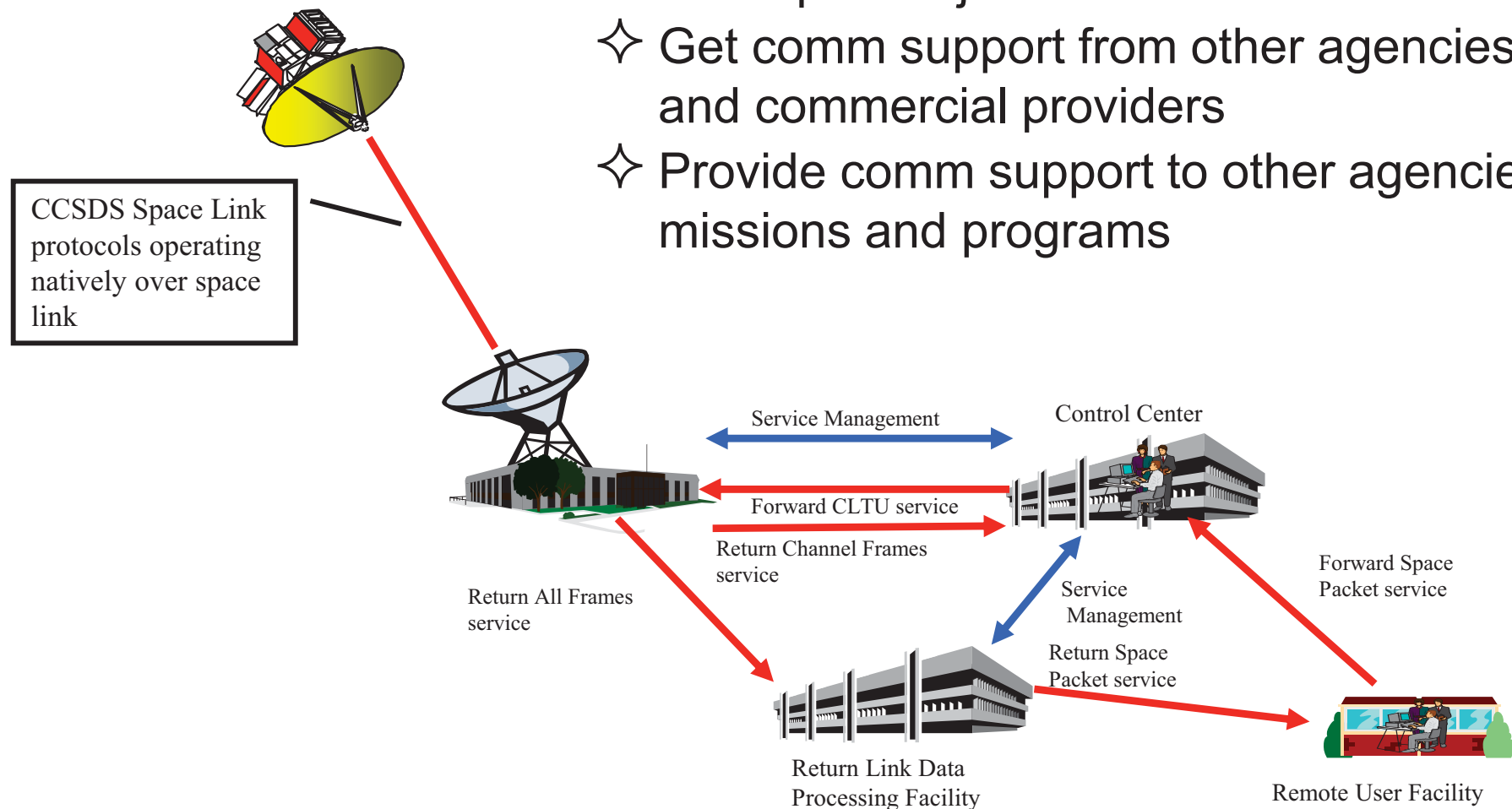
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- ✦ Service association establishment, configuration, and termination
- ✦ Access control and authentication
- ✦ Transfer of CCSDS space link data units with ancillary data, e.g.:
  - ✧ Ground receipt time for return link data
  - ✧ Radiation time window for forward link data
- ✦ Offline storage and retrieval
- ✦ Space link data status information
- ✦ Transfer service status and accounting information
- ✦ Production status information
- ✦ Reliable transmission to multiple service users
- ✦ (Limited) Service management – some mechanisms for control of executing transfer services

# Space Link Extension

## One Example Configuration

- ★ This makes it very cost-effective to:
  - ✧ Participate in joint missions
  - ✧ Get comm support from other agencies and commercial providers
  - ✧ Provide comm support to other agencies' missions and programs



## Benefits of SLE Services

---

- ★ SLE services address more than just data transfer
  - ✧ Connections management, service configuration, status and accounting reports
- ★ SLE services are designed to operate over commercially-available packet network infrastructure
- ★ Common data and management interface simplifies operation of spaceflight missions across multiple space-ground network service providers
- ★ Services are scalable - only those services that are required by a user mission or service provider need be implemented
- ★ Standardized services increase market for space-ground network services providers
- ★ Expanded global market for COTS SLE products: increased number of vendors and/or lower costs for products
- ★ Reduced costs and technical and schedule risks
- ★ SLE places no additional requirements on spacecraft that already use CCSDS space link protocols

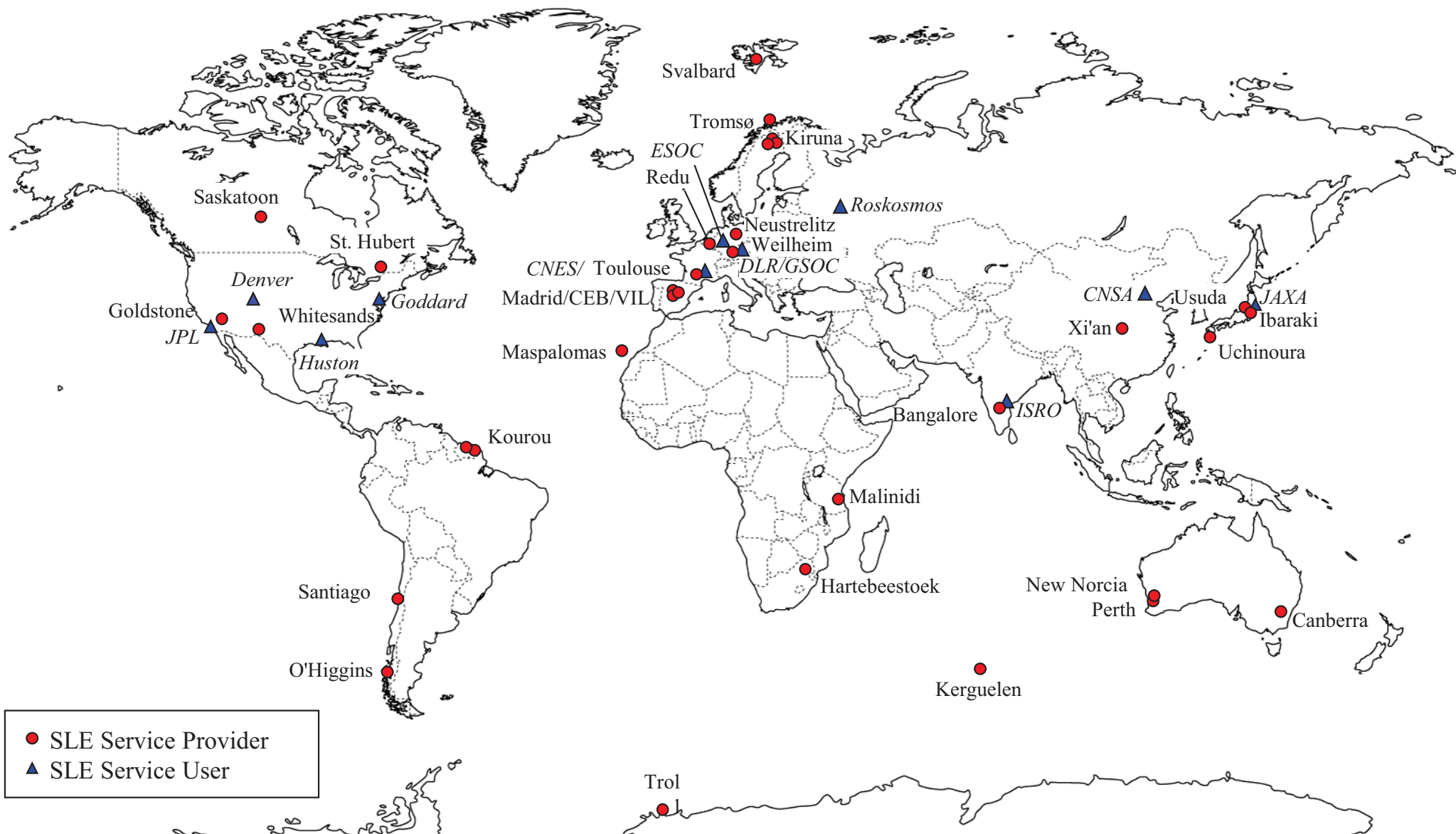
- Seventeen (17) SLE transfer services  
**as identified in SLE Reference Model**
  - Ten (10) forward (uplink) services
    - » Forward CLTU (Command Link Transmission Unit)
    - » Forward TC (Telecommand) Frame
    - » Forward TC-VCA (Virtual Channel Access)
    - » Forward Space Packet
    - » Forward proto-VCDU (Virtual Channel Data Unit)
    - » Forward Insert
    - » Forward C/VCDU ((Coded)/VCDU)
    - » Forward VCA
    - » Forward Bitstream
  - Seven (7) return (downlink) services
    - » Return All Frames
    - » Return Insert
    - » Return Channel Frames
    - » Return FSH (Frame Secondary Header)
    - » Return OCF (Operations Control Field)
    - » Return Bitstream
    - » Return Space Packet

## *Notes:*

- **Not all of these are published Standards;**  
*see CCSDS website for published SLE standards*
- *A next generation framework for data transfer standards is in progress (more on next slides)*
- *This list may be revised as more*



# SLE Success Story (2002 to 2009)



## This is all great, but....

---

- ✦ Seventeen (17) SLE transfer services → 17 separate recommendations, prototyping, sets of agency reviews, maintenance issues, etc
  - ✧ Recommendations tended to be duplicative in terms of substantial technical content
  - ✧ CCSDS should be able to do something better...
- ✦ CCSDS decided to take a new approach that factors all of the common technical stuff into a re-usable framework and re-use framework to meet agency needs for inter-operation, data transfer, including data that does not necessarily have a spacelink component
  - ✧ E.g, what about ground station service production monitor data?

# Transition from SLE to CSTS

- ✦ The Cross Support Transfer Services (CSTS) are designed to pick up where SLE left off:
  - ✧ Creating new services (not duplicating SLE services) which are needed for future missions
  - ✧ Doing that in a new way – with a simpler architecture around a reusable framework.
  - ✧ Unfortunately, the new way (reusable framework) makes CSS not compatible/interoperable with SLE.
  - ✧ The CCSDS agencies have decided to leave SLE capabilities in place while adding CSTS capabilities for new functions
- ✦ As a result, agencies are expected to implement both SLE and CSTS, depending on the capabilities they need to interface with at their and others' comm sites.
  - ✧ First implementing SLE as the core mechanism
  - ✧ Then implementing CSTS as the supplemental mechanism for new needs
- ✦ Similarly CSSM will add new management services that supplement what is currently done with SLE... management of ground station and antenna site functions remotely from the user facility (MCC, etc.).

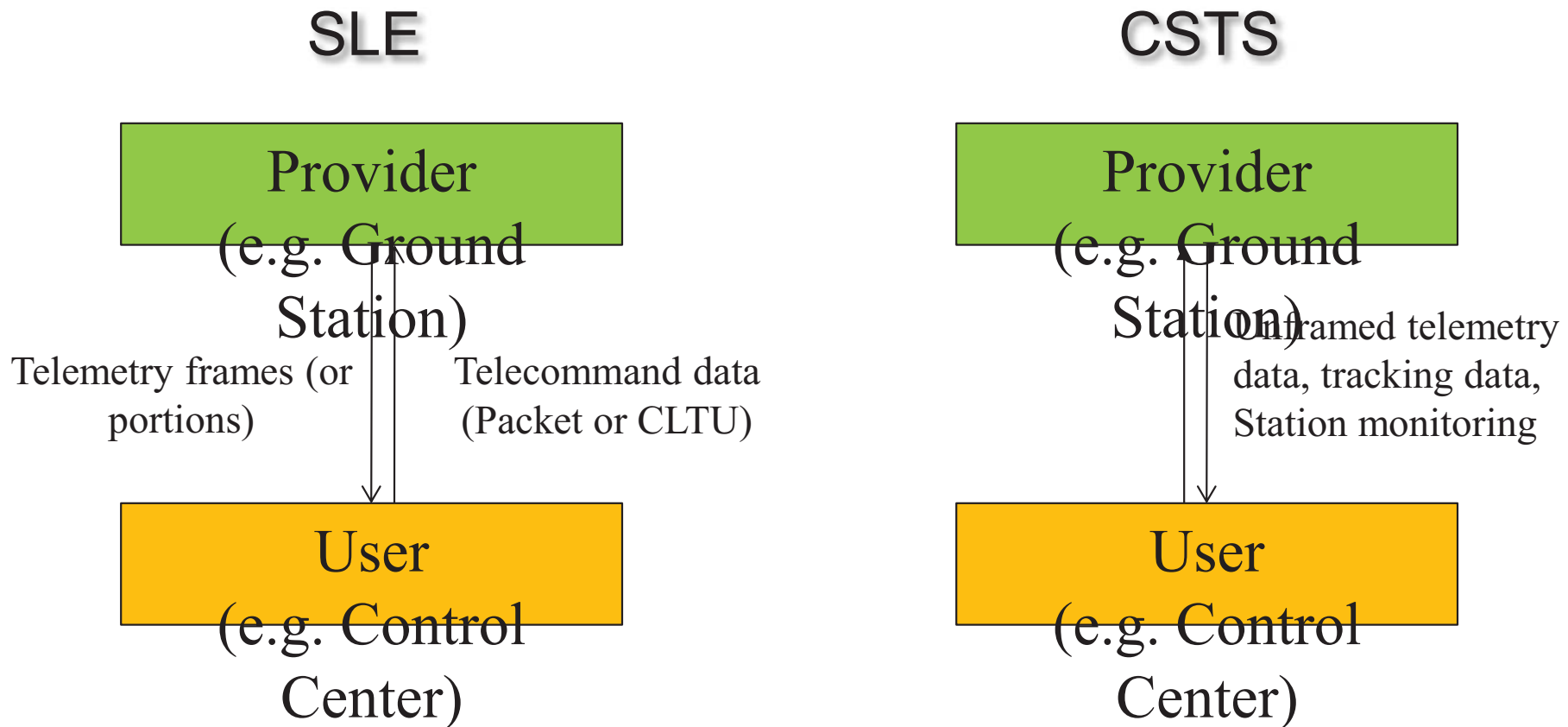


# Cross Support Transfer Services (CSTS)

## Overview

# CSTS builds on SLE success (1)

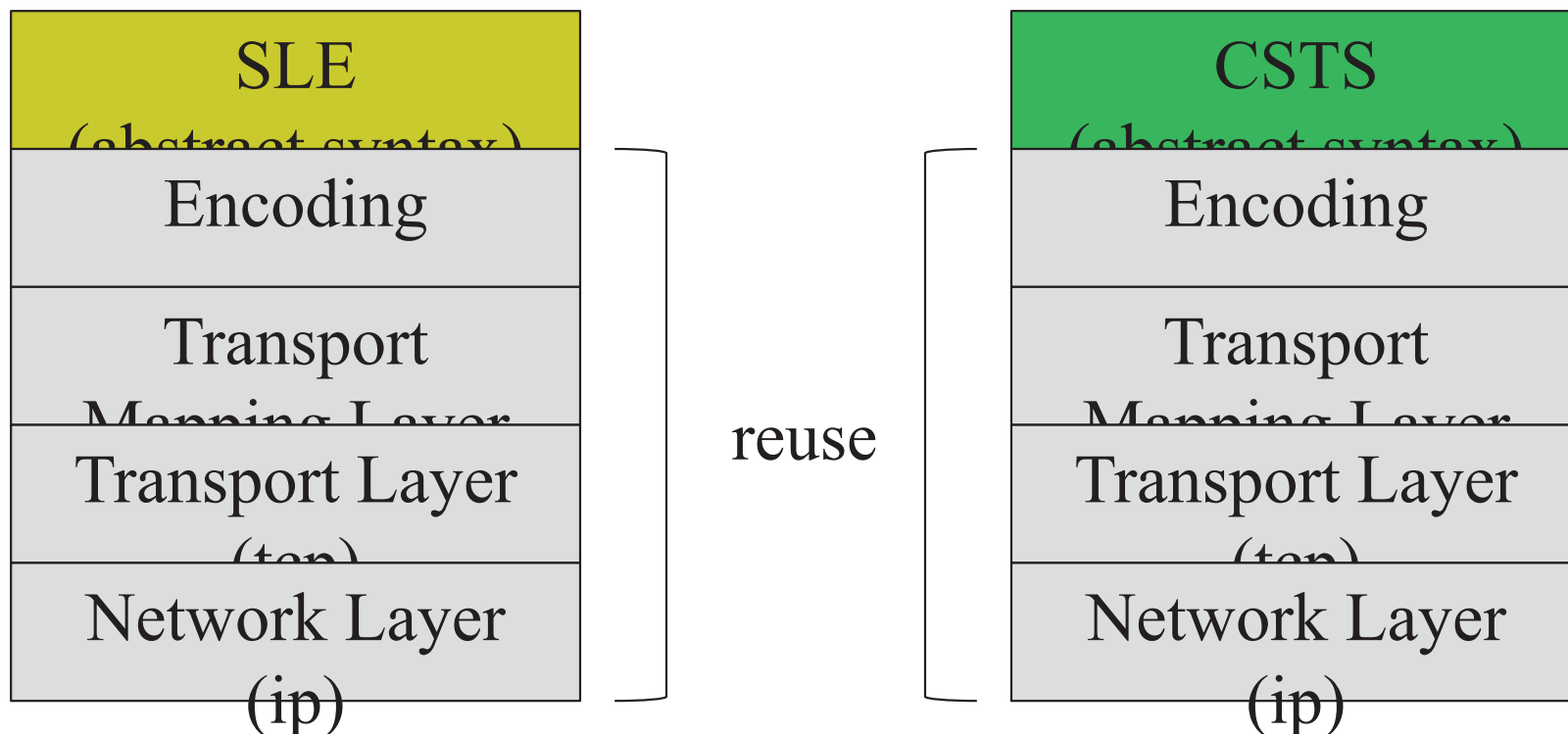
CSTS builds on SLE success by supporting additional types of data.



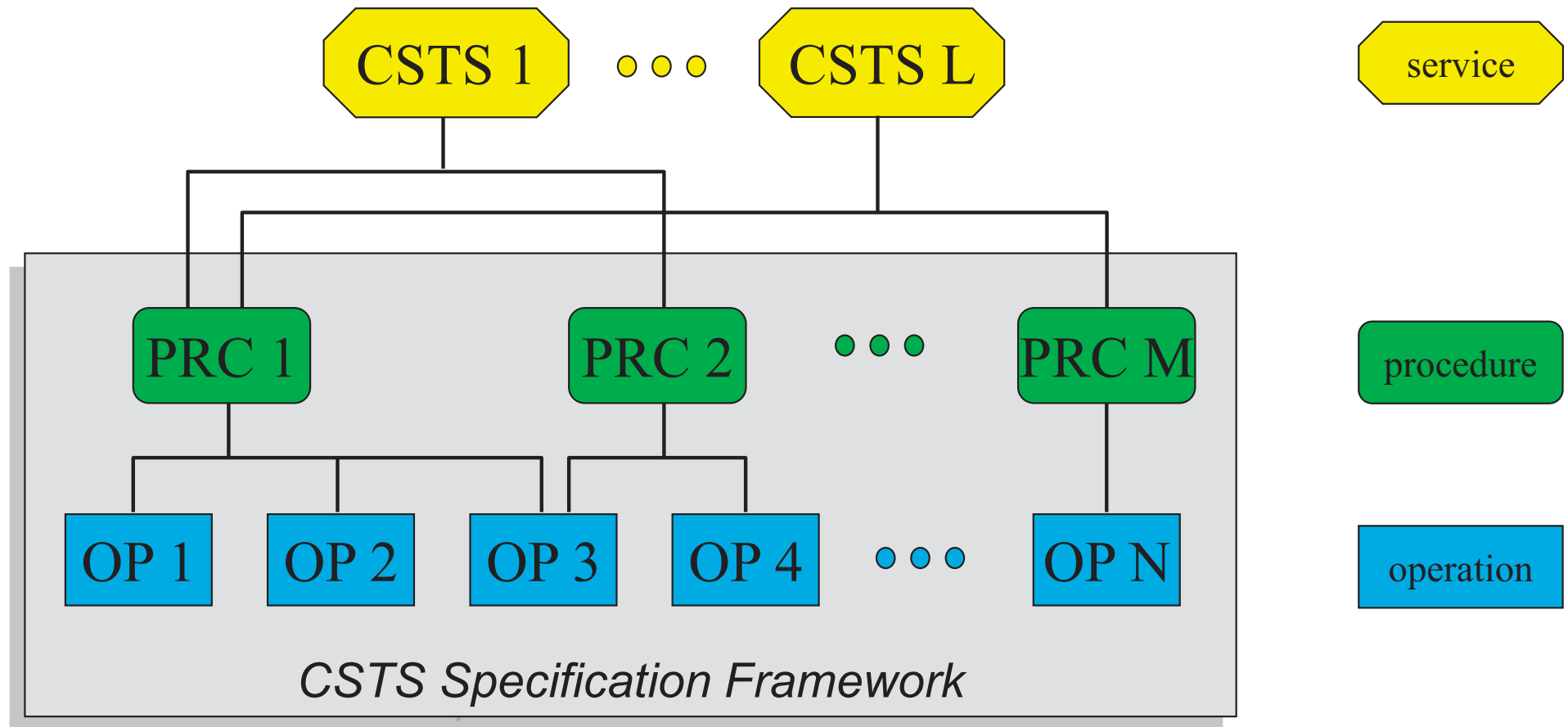


## CSTS builds on SLE success (2)

CSTS reuses all the protocol layers underneath SLE, as well as the abstract syntax concept for its protocol messages.



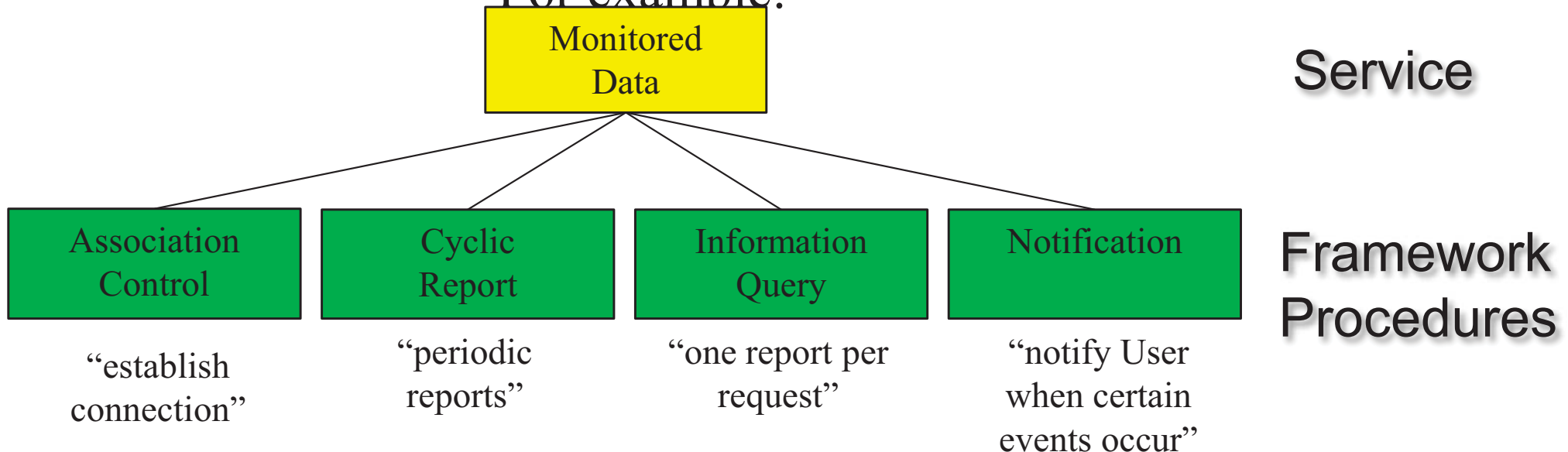
The CSTS Framework provides a reusable foundation that allows services to be defined and implemented efficiently.



# CSTS Services use the Framework

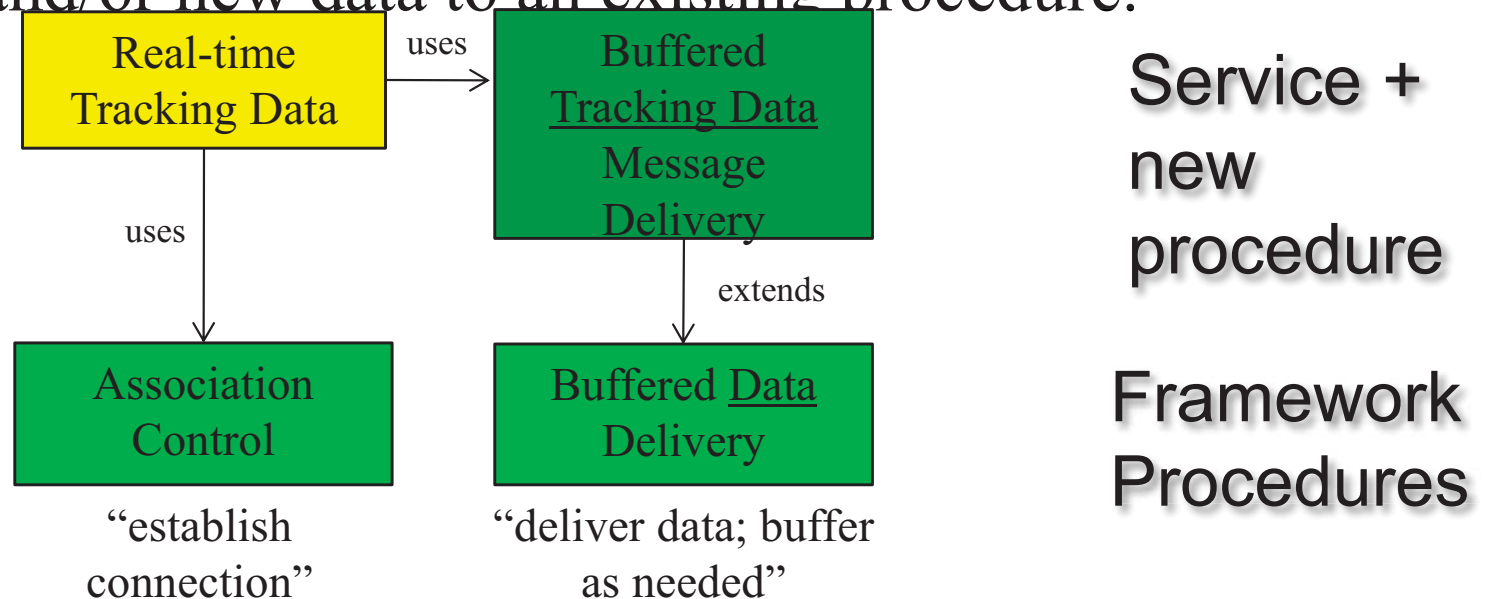
Each service uses only those Framework procedures that are needed to get the job done.

For example:



## A CSTS service may extend the Framework

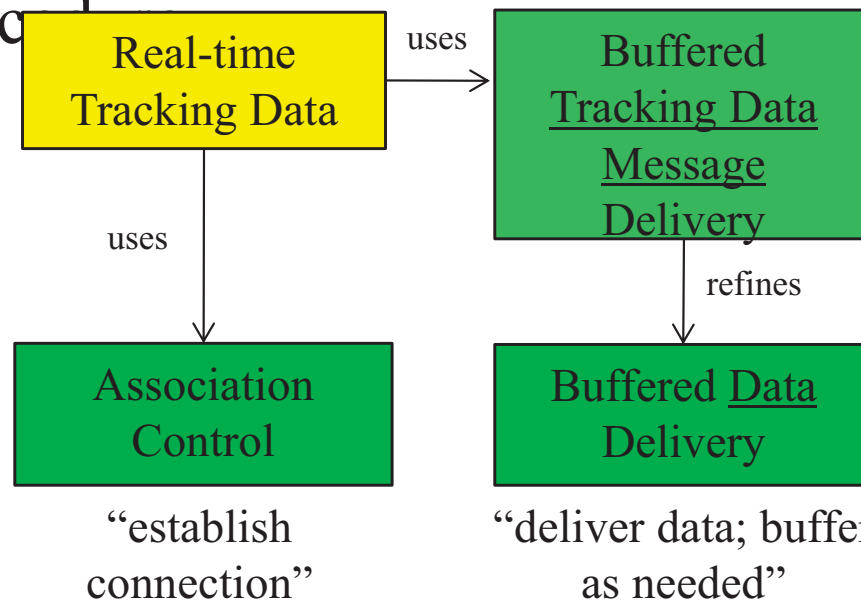
If a service needs capabilities that are not supplied by the Framework, it may extend the Framework – it can create a new procedure that adds new behavior and/or new data to an existing procedure.



The new procedure adds one capability to the existing procedure - it delivers one *context* message prior to a stream of *Tracking Data* messages.

# A CSTS service may refine the Framework

If a service needs more precise capabilities than the abstract capabilities provided by the Framework, it may refine the Framework - for example, a new procedure narrows the possibilities provided by an existing procedure.



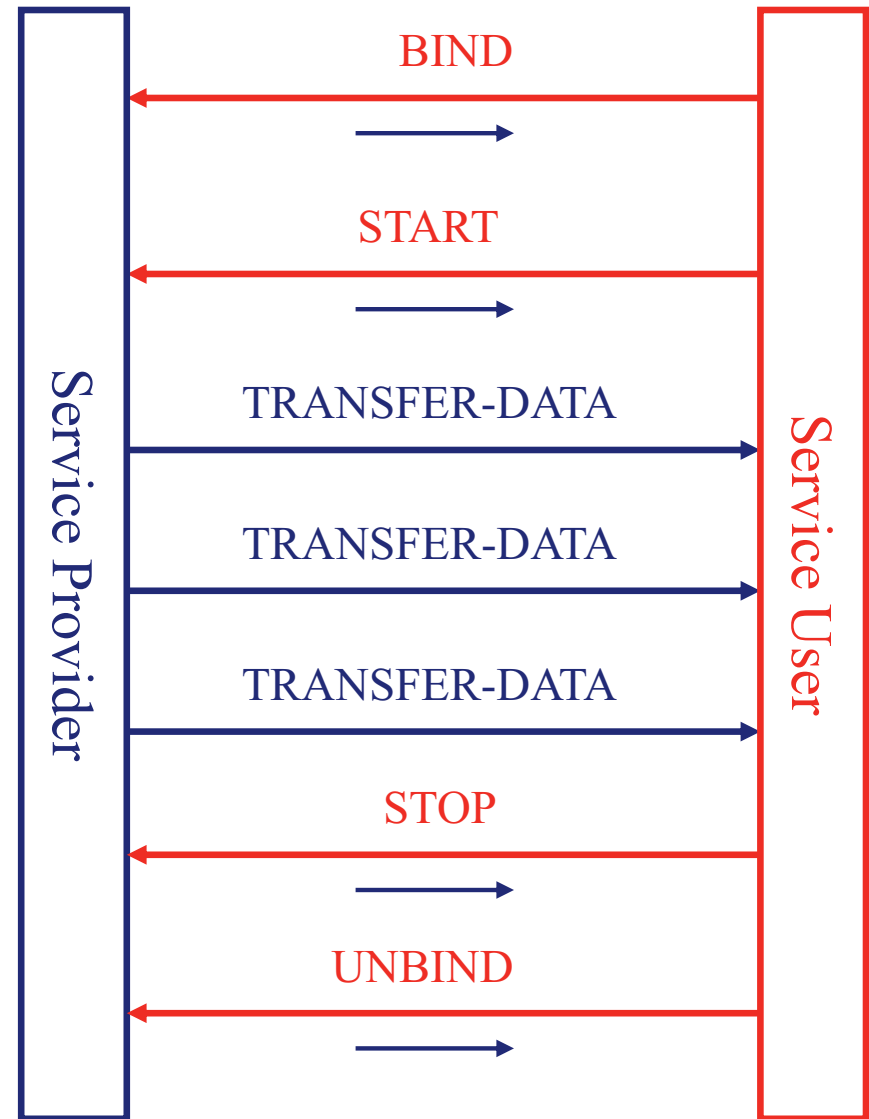
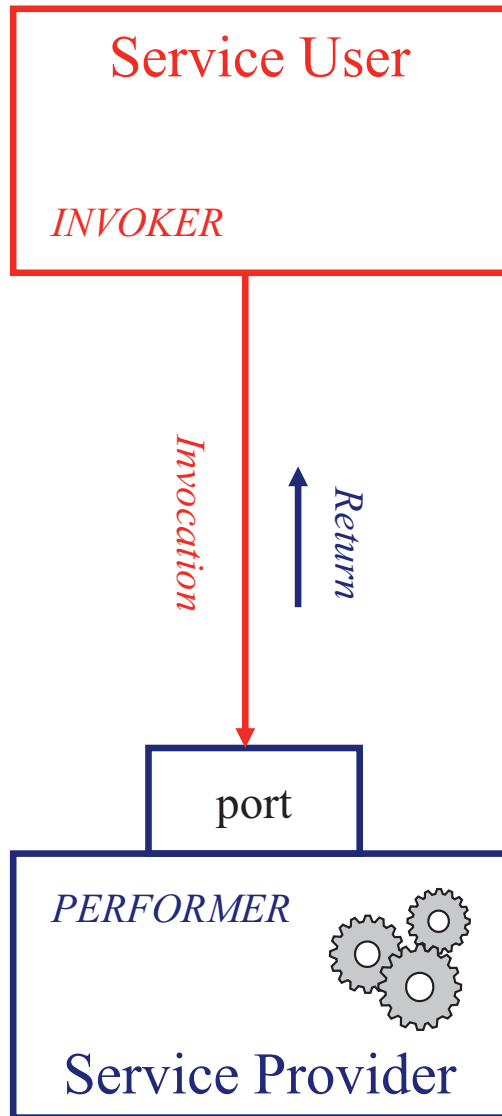
Service +  
derived  
procedure

Framework  
Procedures

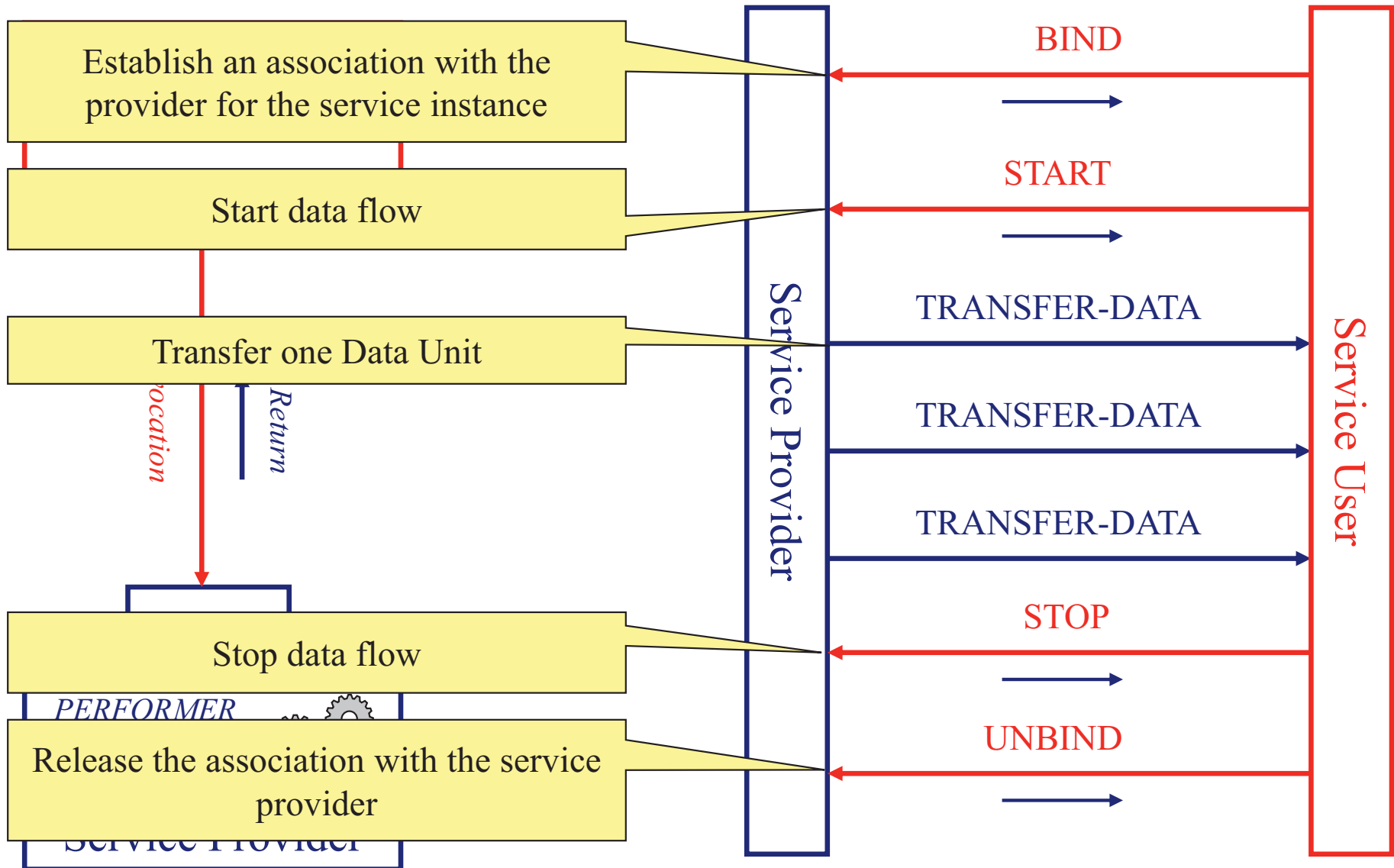
The Buffered-Data-Delivery procedure does not specify the format of the data to be delivered; the new procedure specifies that the data will match the standard Tracking Data Message format.



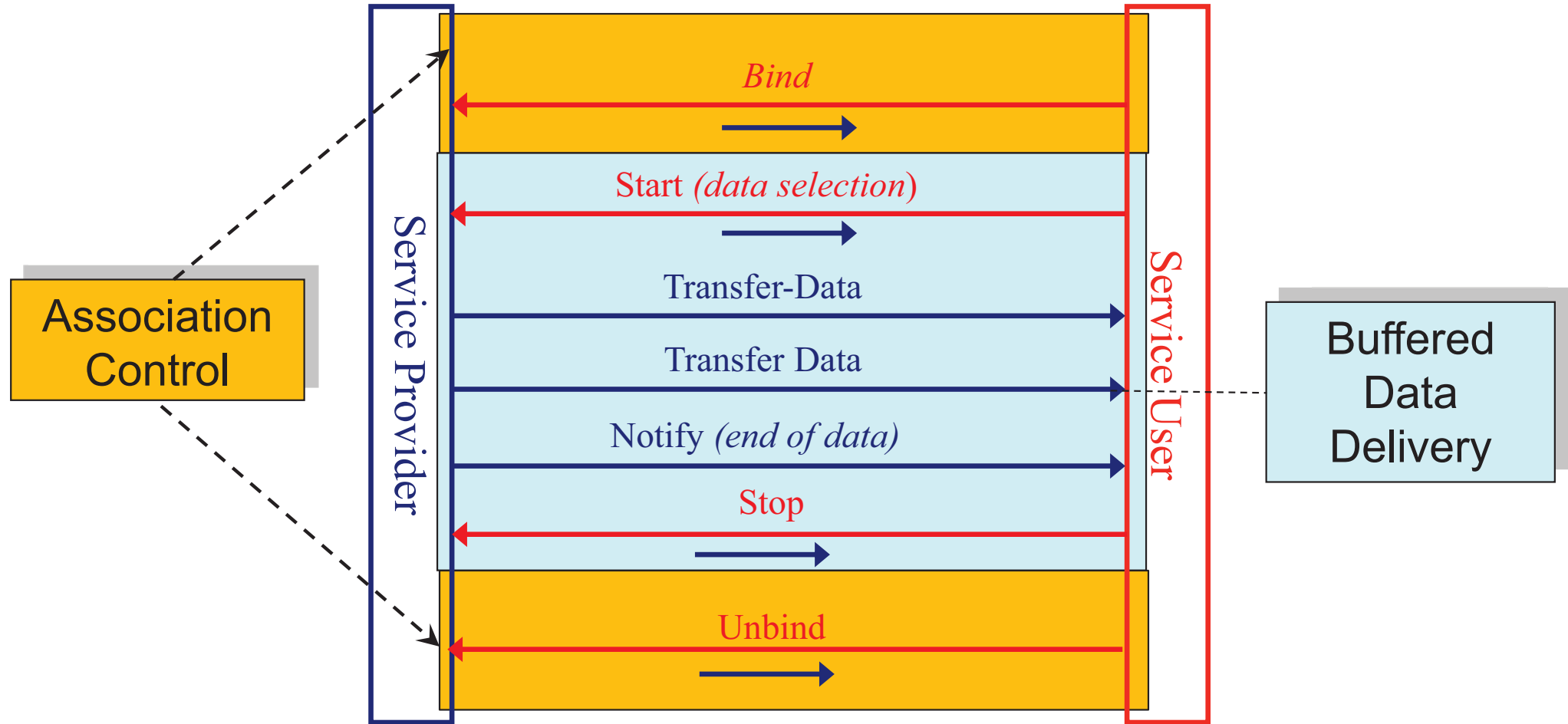
# CSTS Lower-layer Building Block – Operations



# CSTS Lower-layer Building Block – Operations



# CSTS Higher-layer Building Block - Procedures



Note: The Buffered Data Delivery procedure includes mechanisms for buffering and releasing of data units.

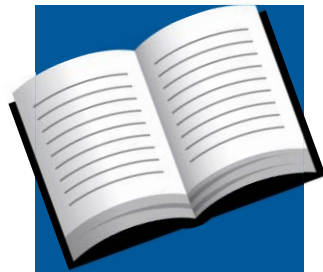
# CCSDS CSTS Major Documents



GREEN BOOK – Informative Report  
Cross Support Transfer Service  
Specification Framework Concepts

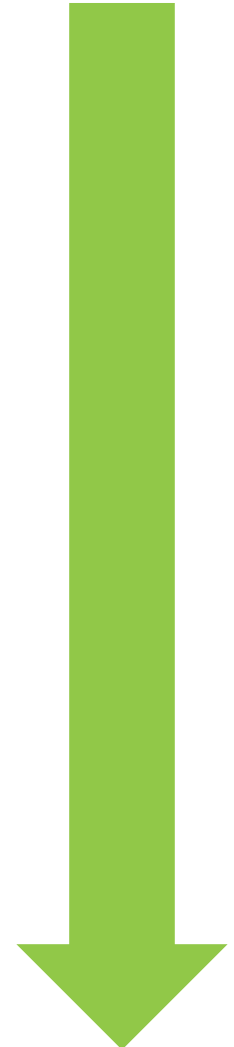


MAGENTA BOOK – Recommended  
Practice  
Guidelines for Specification of  
Cross Support Transfer Services



BLUE BOOK – Recommended Standard  
Cross Support Transfer Service  
Specification Framework

Increasing Level  
Of Detail and  
Specification



Current draft of Framework Blue Book is available in the private area of CCSDS CWE for WG participants, or it can be provided on request. **HOWEVER**, be careful not to implement systems to that specification until it is approved by CCSDS.

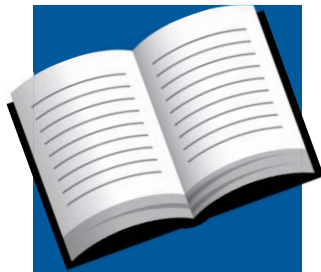
# CCSDS CSTS Major Documents



- ★ The **Concepts report** explains:
  - ✧ How the Framework fits into the bigger picture.
  - ✧ The approach taken within the Framework
  - ✧ Capabilities that are assumed to be provided by protocol layers below the Framework.
  - ✧ How to use the Framework to build a service.



- ★ The **Guidelines specification** is intended to guide people who want to create new services. This specification attempts to ensure that:
  - ✧ Services make maximum use of the reusable Framework.
  - ✧ When a service extends the Framework, that it does so in the most efficient way that is practical.
  - ✧ Service specifications follow a consistent outline.
  - ✧ Services are consistent in how they use Service Management to configure themselves.



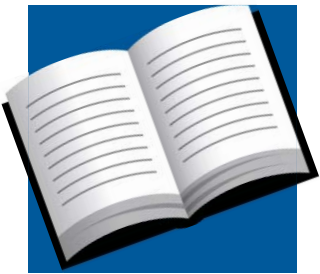
- ★ The **Framework specification** defines the procedures and operations that make up the Framework. This includes specifying the format of all CSTS protocol messages.



# CSTS - Reading the Framework specification

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- ✦ For managers and others interested in the bigger picture, sections 1 and 2 are recommended.
- ✦ For implementers and others interested in the detailed rules to be followed, sections 3 and 4 are recommended.
- ✦ Note that the formal definition of protocol message formats is found in Annex C.



## CSTS Conclusions

---

- ✦ The CSTS Framework builds on proven SLE concepts, and much of the source code developed for SLE can be reused for CSTS.
- ✦ The CSTS Framework provides an efficient path to defining and implementing new services – it enables savings in time and cost.
  - ✧ The Framework specification provides building blocks that can be used to build new services.
  - ✧ These building blocks can easily be extended and/or refined as necessary.
- ✦ While it is possible to transition the existing SLE services to the CSTS approach, there are no plans to do so at this time.

## ...But it all needs to be managed...

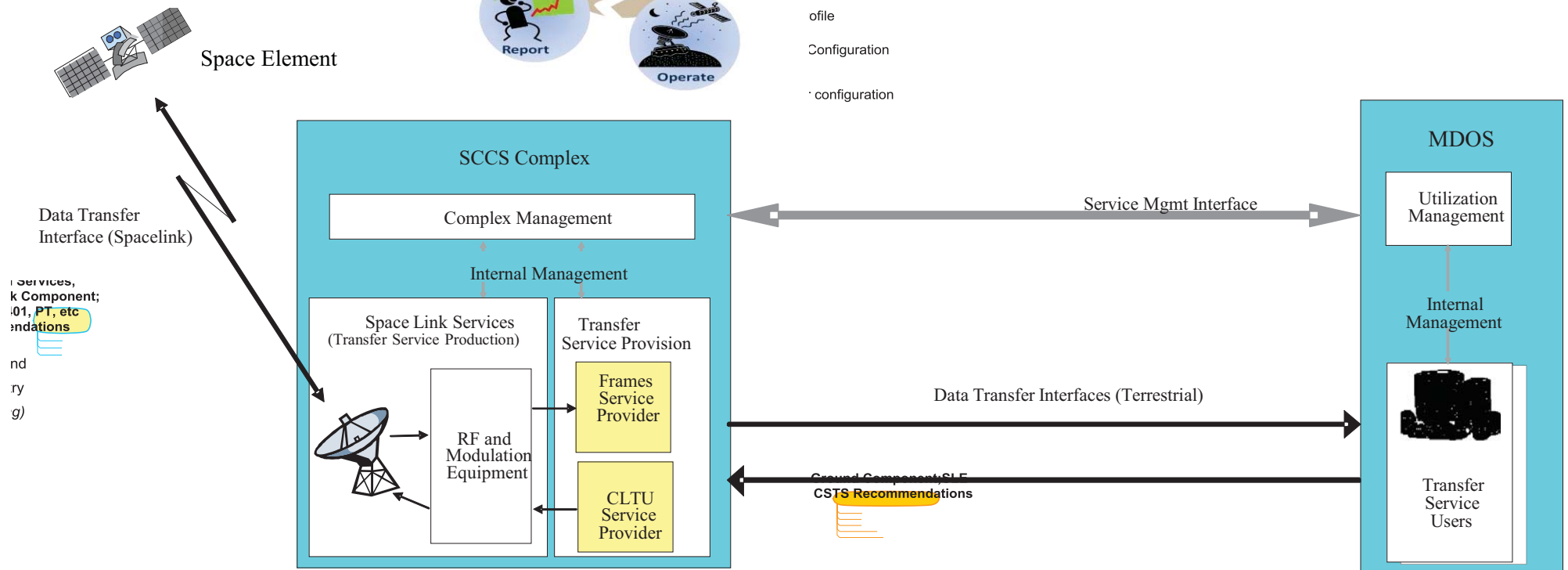
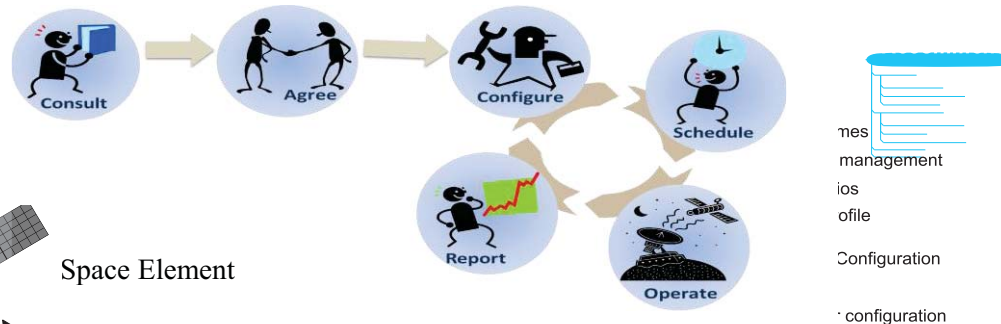
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- ✦ Real-world spacecraft tracking requires planning and coordination of many different types of information ranging from spacecraft telecommunications capabilities, to trajectory data, to real-time service execution control to accounting for services rendered.
- ✦ Define an approach that factors all of the common technical stuff into a re-usable framework and re-use framework to meet agency needs for inter-operation, data transfer, including data that does not necessarily have a spacelink component
  - ✧ E.g, what about ground station service production monitor data?
- ✦ The CCSDS Cross Support Service Management (CSSM) project was created to answer that need.

# Cross Support Service Management (CSSM) A Brief Overview

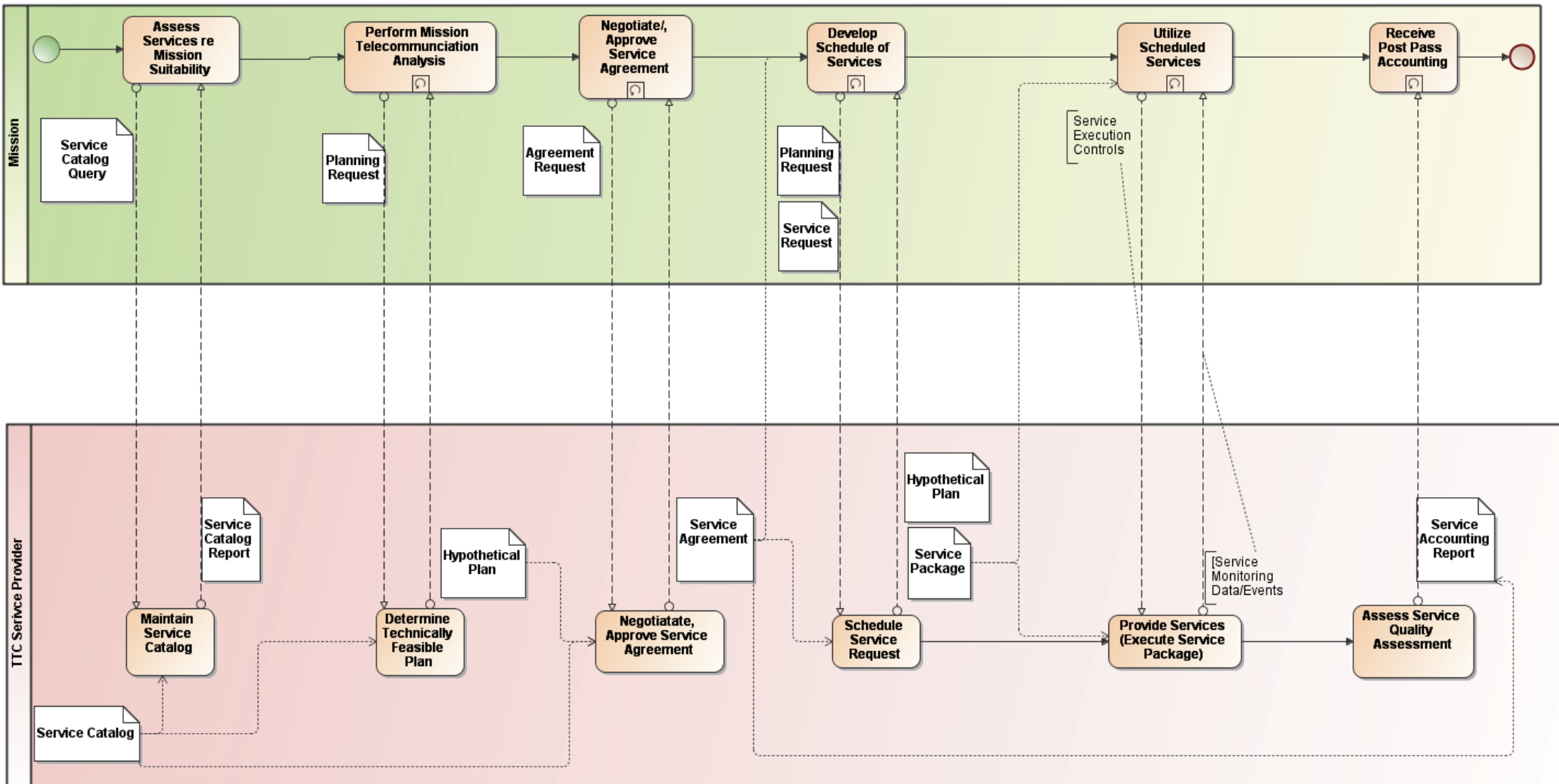
## ★ Objective

- ✧ Define management service standards for cross support management of Telemetry, Command, Ranging and future CCSDS inter-agency services



1)

# The CCSDS Service Management Lifecycle



# Current CCSDS Service Management Projects

- ✦ **Service Catalog** – definition of how to state characteristics of TTC Services offered; telemetry services supported at S, X bands up to 50 Mbps, with LDPB coding
- ✦ **Planning Information** – definition of planning information such as predicted communication geometry
- ✦ **Schedule of Services** – definition of data format for publication of network schedules
- ✦ **Configuration/Service** Agreement information – definition of space link, terrestrial data transfer (i.e. SLE and CSTS), and levels of services to be provided (for example number of spacecraft contacts for a given period of time)
- ✦ **Service request/service package** – definition of a request for TTC network services and response for such a request
- ✦ **Event Sequence** – Definition of how spacecraft, especially those in deep space, may change the configuration such that the ground systems can respond properly when it is impossible to convey the changes in real time (i.e. preplanning required because of long light time delays)
- ✦ **Service Accounting** – definition of accounting for services and qualities of services rendered; e.g, 1.2 million telemetry frames returned; 99% successful decoding



# Cross Support Services Area

## Current CSS Projects

### ✦ CSTS and CSSM Project Status

✧ Red cells indicate important support is needed

✧ NSPO participation in these WGs is welcome

Project	Working Group	Doc type	Book Editor	Prototype 1	Prototype 2	Contributors
Cross-Support Specification Framework	CSTS WG	Blue	ESA	ESA	NASA	CNES, DLR, ESA, NASA
Cross-Support-Transfer Services Specification Framework Concept	CSTS WG	Green	DLR	N/A	N/A	CNES, DLR, ESA, NASA
Guidelines for Specification of Cross Support Transfer Services	CSTS WG	Magenta	DLR	N/A	N/A	CNES, DLR, ESA, NASA
Monitored Data - Cross Support Transfer Services	CSTS WG	Blue	NASA	CNES	NASA	CNES, DLR, ESA, NASA
SLE API for Return All Frames Service. Magenta Book: M-1 Update	CSTS WG	Magenta	DLR	N/A	N/A	CNES, DLR, ESA, NASA
SLE API for Return Channel Frames Service: M-1 Update	CSTS WG	Magenta	DLR	N/A	N/A	CNES, DLR, ESA, NASA
SLE API for Return Operational Control Fields: M-1 Update	CSTS WG	Magenta	DLR	N/A	N/A	CNES, DLR, ESA, NASA
SLE API for the Forward CLTU Service. Magenta Book: M-1 Update	CSTS WG	Magenta	DLR	N/A	N/A	CNES, DLR, ESA, NASA
SLE API for the Forward Space Packet Service: M-1 Update	CSTS WG	Magenta	DLR	N/A	N/A	CNES, DLR, ESA, NASA
SLE API for Transfer Services—Core Specification: M-1 Update	CSTS WG	Magenta	DLR	N/A	N/A	CNES, DLR, ESA, NASA
Tracking Data Cross support Transfer Service	CSTS WG	Blue	NASA			CNES, DLR, ESA, NASA
CSSM Service Agreement and Service Config Profile Data Formats	CSSM WG	Blue				
CSSM Simple Schedule Format Specification	CSSM WG	Blue	ESA	DLR	NASA	CNES, DLR, ESA, NASA
CSSM Event Sequence Data Format	CSSM WG	Blue				
CSSM Planning Data Formats	CSSM WG	Blue	ESA	NASA	ESA	DLR, ESA, JAXA, NASA
CSSM Service Accounting	CSSM WG	Blue				
CSSM Service Catalog	CSSM WG	Blue				
CSSM Service Request and Service Package Data Formats	CSSM WG	Blue				
Extensible Space Comm CSSM -- Concept	CSSM WG	Green	NASA	N/A	N/A	ESA, NASA

## Conclusions

---

- ✦ NSPO would benefit from:
  - ✧ Adopting existing SLE standards
  - ✧ Helping to develop new CSS Area Standards (CS Transport Services and CS Service Management)
- ✦ Because...
  - ✧ After initial investment, these solutions are long-term more cost effective
  - ✧ Provides ability for NSPO to use other agencies' comm assets
  - ✧ Provides ability for NSPO to provide services to other agencies from NSPO comm assets
  - ✧ SLE software code is partly reusable for CSTS projects
  - ✧ NSPO participation in CCSDS can make CSTS and CSSM better aligned with NSPO needs

# Backup Material

# Field Guide to CCSDS Book Colors



## BLUE BOOKS

### Recommended Standards

Normative and sufficiently detailed (and pre-tested) so they can be used to directly and independently implement interoperable systems (given that options are specified).



## ORANGE BOOKS

### Experimental

Normative, but may be very new technology that does not **yet** have consensus of enough agencies to standardize.



## MAGENTA BOOKS

### Recommended Practices

Normative, but at a level that is not directly implementable for interoperability. These are Reference Architectures, APIs, operational practices, etc.



## YELLOW BOOKS

### Administrative

CCSDS Procedures, Proceedings, Test reports, etc.



## GREEN BOOKS

### Informative Documents

Not normative. These may be foundational for Blue/Magenta books, describing their applicability, overall architecture, ops concept, etc.



## SILVER BOOKS

### Historical

Deprecated and retired documents that are kept available to support existing or legacy implementations. Implication is that other agencies may not cross-support.



## RED BOOKS

### Draft Standards/Practices

Drafts of future Blue/Magenta books that are in agency review. Use caution with these... they can change before release.



## PINK BOOKS/SHEETS

### Draft Revisions For Review

Draft Revisions to Blue or Magenta books that are circulated for agency review. Pink Books are reissues of the full book, Pink Sheets are change pages only.

# CCSDS Overview

## End-to-End Architecture

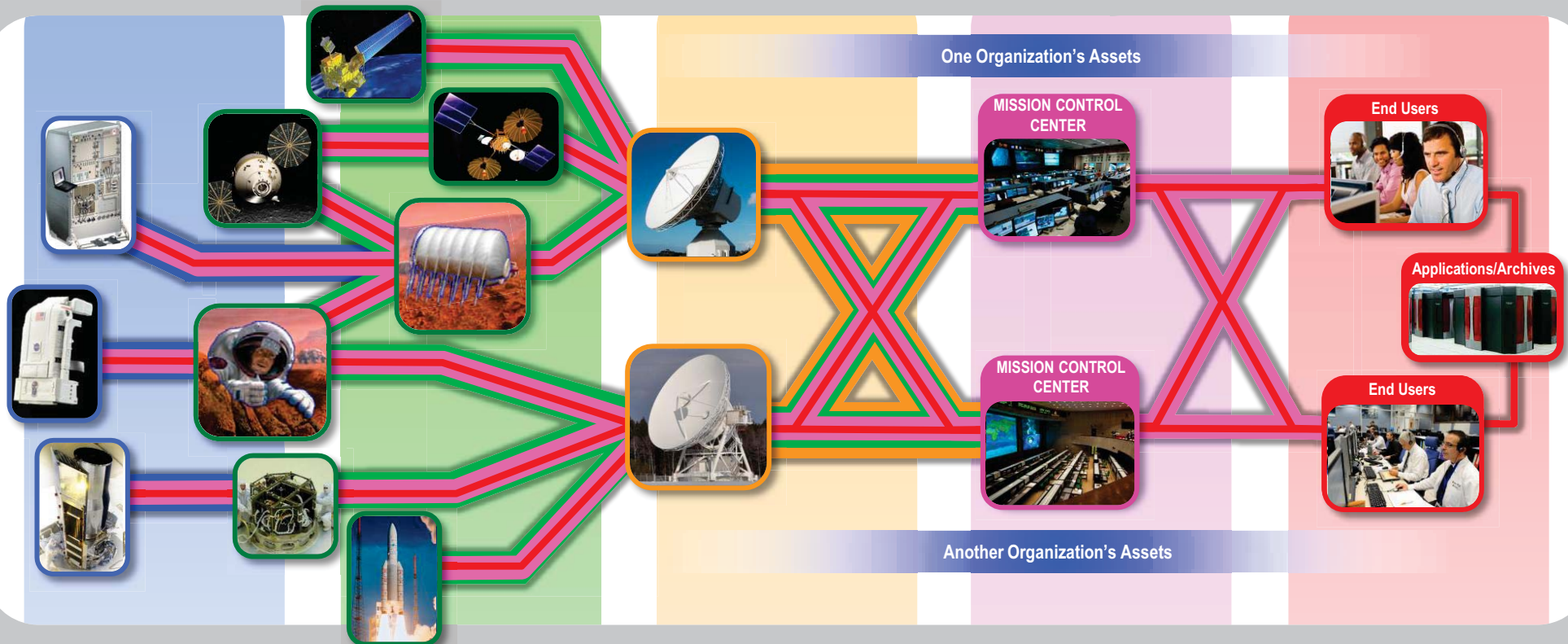
### Six Areas

### Twenty-Eight working groups

- ◆ Working Group (producing standards)
- ◆ Birds-Of-a-Feather stage (pre-approval)
- ◆ Special Interest Group (integration forum)

### Systems Engineering

- ◆ Security
- ◆ Space Assigned Numbers Auth.
- ◆ Delta-DOR
- ◆ Timeline Data Exchange
- ◆ Standards and Guidelines



### Spacecraft Onboard Interface Services

- ◆ Onboard Wireless WG
- ◆ Application Supt Services (incl. Plug-n-Play)

### Space Link Services

- ◆ RF & Modulation
- ◆ Space Link Coding & Sync.
- ◆ Multi/Hyper Data Compress.
- ◆ Space Link Protocols
- ◆ Next Generation Uplink
- ◆ Space Data Link Security
- ◆ Planetary Communications
- ◆ Optical Coding and Mod

### Cross Support Services

- ◆ CS Service Management
- ◆ CS Transfer Services
- ◆ Cross Supt Service Arch.

### Space Internetworking Services

- ◆ Asynchronous Messaging
- ◆ Motion Imagery & Apps
- ◆ Delay Tolerant Networking
- ◆ Voice
- ◆ CFDP over Encap

### Mission Ops & Info Mgt Services

- ◆ Data Archive Ingestion
- ◆ Navigation
- ◆ Spacecraft Monitor & Control
- ◆ Digital Repository Audit/Certification
- ◆ Telerobotics



# Debris Avoidance and the CCSDS Navigation Working Group

Presentation to NSPO in Taiwan  
November 2013



**Mike Kearney**  
CCSDS Chair & General Secretary  
NASA MSFC EO-01  
256-544-2029  
[Mike.Kearney@nasa.gov](mailto:Mike.Kearney@nasa.gov)



- ★ The CCSDS Navigation Working Group is chartered to develop standards covering exchange of spaceflight dynamics related data
- ★ Past Progress and Current Work
  - ✧ Orbit Data Messages (version 2.0 published 11/2009)
    - ◆ Three standard message formats for exchanging orbit descriptions
  - ✧ Tracking Data Message (version 1.0 published 11/2007)
    - ◆ Message format for exchanging tracking data; supports widely used tracking data types: Doppler, range, angle,  $\Delta$ DOR, ancillary information
  - ✧ Attitude Data Messages (version 1.0 published 05/2008)
    - ◆ Two message formats for exchanging spacecraft attitude descriptions
  - ✧ Navigation Green Book (version 3.0 published 05/2010)
    - ◆ Contains technical background related to the Nav WG Recommendations
  - ✧ Nav Data Messages XML Specification (version 1.0 published 12/2010)
    - ◆ Contains XML representations of all above Nav WG standards
  - ✧ Conjunction Data Message (pub June 2013)
    - ◆ Standard message format for informing spacecraft operators of object conjunctions in space (spacecraft/spacecraft, spacecraft/debris, debris/debris)
- ★ Future work
  - ✧ Pointing Requests Message – communicating complex on-orbit cross-support pointing requests (e.g., inertial, limb, terminator, velocity, nadir, track)
  - ✧ Navigation Hardware Message – exchanging onboard navigation H/W data between space agencies (e.g., thrusters, accelerometers, star trackers, etc.)
  - ✧ Spacecraft Maneuver Message – exchanging information regarding spacecraft maneuvers (requirements, design, reconstructed performance)

# Navigation WG - Scope

- ✦ The CCSDS Conjunction Data Message provides a warning of a predicted spacecraft conjunction
  - ✧ It does not specify how to make such a prediction nor what to do in the event of a warning
  - ✧ This is consistent with the approach taken for all of the CCSDS flight dynamics related standards
- ✦ The NAV WG standardized the format in which a trajectory designed/determined by one party could be exchanged with another party.
- ✦ It also standardized a format for exchanging the tracking data that could be input to an orbit determination process.
- ✦ It also standardized the format in which attitude state(s) designed/determined by one party could be exchanged with another party.
- ✦ The NAV WG did NOT standardize:
  - ✧ the process of orbit determination or designing a trajectory
  - ✧ the process of attitude determination or design
  - ✧ the process of analyzing spacecraft conjunctions, but we did standardize the format in which a conjunction warning analyzed by one party could be conveyed to the affected satellite operator(s).
  - ✧ what one might do in the event that they received a conjunction warning.
    - ◆ There are too many variables, and some implied liabilities to making recommendations in this area.

## Recommendations on Navigation Ops Research

- ✦ US StratCom (Strategic Command) has hosted technical workshops on Navigation and Collision Avoidance topics in the US, Europe and Japan.
  - ✧ NSPO has not attended as far as they know
  - ✧ Recommend participating in future events
  - ✧ (Contact info?)
- ✦ Recommendation: Request the Conjunction Summary Message from JSPOC.
  - ✧ Available via [www.space-track.org](http://www.space-track.org) (login required)
  - ✧ Send email to Ms. Diana McKissock ([diana.mckissock.1@us.af.mil](mailto:diana.mckissock.1@us.af.mil))
  - ✧ Include a list of satellites that NSPO operates, and a list of e-mail addresses for people in their organization who are authorized to have access to that data.
- ✦ Operational Information from NASA GSFC is publically available:
  - ✧ [\*NASA Robotic Conjunction Assessment Process - AIAA Info\*](#)
  - ✧ Addresses safety volumes, etc.

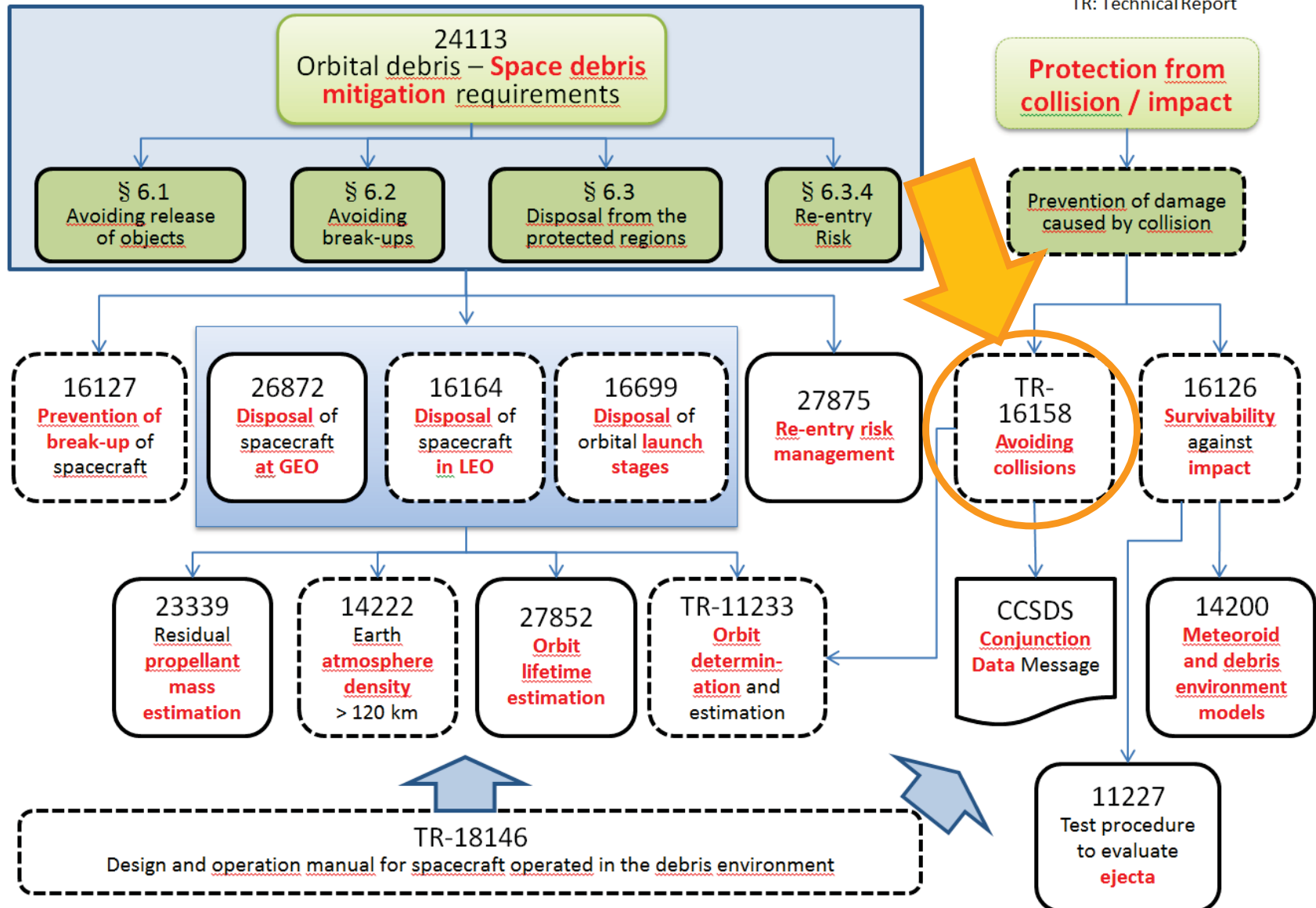
- ✦ CCSDS only works on data exchange for navigation
- ✦ CCSDS functions as ISO TC20/SC13
- ✦ Our “Sister” organization is ISO TC20/SC14.
  - ✧ They develop spaceflight standards for processes, algorithms, procedures, etc.
- ✦ ISO TC20/SC14/WG3 has over the past few years initiated attempts to develop international standards in some of these areas, but later changed the document types to "Technical Report" (the equivalent of a CCSDS Green Book).
  - ✧ This is TR-16158, “Avoiding Collisions”
- ✦ The complete ISO document tree on Debris avoidance is on the next chart.

# ISO TC20/WG14 Documents on Debris Mitigation



## Structure of ISO Space Debris Mitigation Standards

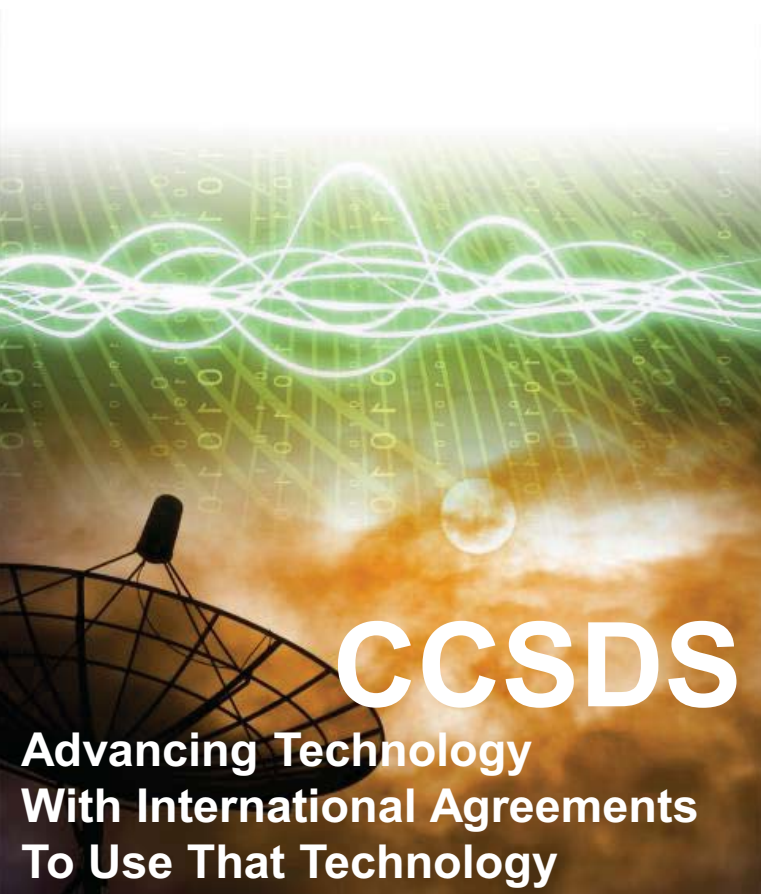
not published yet  
TR: Technical Report



Published ISO standards can be obtained from [www.iso.org](http://www.iso.org)

# CCSDS Applied To Remote Sensing Programs

Presentation to NSPO in Taiwan  
November 2013



**Mike Kearney**  
CCSDS Chair & General Secretary  
NASA MSFC EO-01  
256-544-2029  
[Mike.Kearney@nasa.gov](mailto:Mike.Kearney@nasa.gov)



# Agenda

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- ✦ CCSDS Background
- ✦ CCSDS Architecture
- ✦ CCSDS Areas of Interest to Remote Sensing Programs
- ✦ Summary

# CCSDS – Scope and Origins

- ✦ CCSDS = The Consultative Committee for Space Data Systems
- ✦ The primary goal of CCSDS is **interoperability** between communications and data systems of space agencies' vehicles, facilities, missions and programs.
- ✦ Of all of the technologies used in spaceflight, standardization of **communications and data systems** brings the most benefit to multi-agency interoperability.
- ✦ CCSDS Started in 1982 developing standards at the lower layers of the protocol stack. The CCSDS scope has grown to cover standards throughout the entire ISO communications stack, plus other Data Systems areas (architecture, archive, security, XML exchange formats, etc).



# Future Mission Drivers

**PAST**

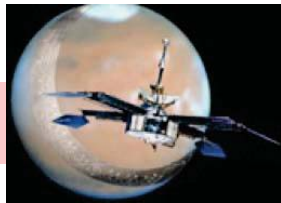
**PRESENT**

**DRIVERS FOR THE**

**FUTURE**



**Shuttle/SpaceLab  
CCSDS packets**



**Brief Recon Flyby,  
Short-Lived Probes  
Direct-to-Earth links**



**Single-Spacecraft  
Survey/Sensors**



**Single-Spacecraft  
Observatories in LEO**



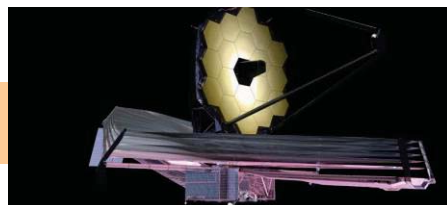
**International Space Station  
Adv. Orbital Sys (AOS)  
Early DTN Prototyping**



**Missions designed for orbital relays,  
Longer duration**



**Spacecraft Constellations  
and formation flying**



**Greater Distances  
Higher bandwidth**

## In Situ Exploration

- Human Expeditions
- Long Duration, High Reliability
- Mobile comm protocols
- Voice, Video, Medical handling
- Onboard Autonomy
- Highly integrated ops

## Complex Deep Space Missions

- Human or robotic exploration
- Longer Duration
- Mobile comm protocols
- Fully automated routing
- Network-Managed DTN
- Optical Communications

## Orbital Remote Sensing

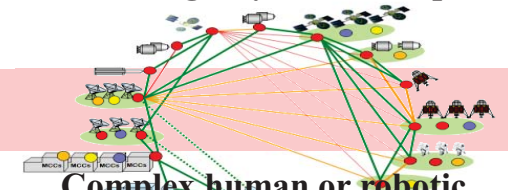
- Long Duration, high bandwidth
- High Spatial, Spectral, & Temporal Resolution
- Low Latency Comm
- Complex link topologies
- *SensorWebs* for synchronized remote sensing

## Next Generation Observatories

- More Capability
- Multiple Spacecraft drive network needs
- Even Greater Capacities require new coding schemes
- Located Even Farther from Earth



**Asteroid/Surface Exploration  
Autonomy, High bandwidth  
Multi-Agency Mission Ops**



**Complex human or robotic  
Scenarios for remote surface missions  
Fully automated Space Internetworking**



**Multi-Discipline and  
Multi-Resource SensorWebs**



**Next Generation  
Observatory Complexes**



# CCSDS Overview

## End-to-End Architecture

### Six Technical Areas, Twenty-Nine Teams

- ◆ Working Group (producing standards)
- ◆ Birds-Of-a-Feather stage (pre-approval)
- ◆ Special Interest Group (integration forum)

#### Systems Engineering

- ◆ Security
- ◆ Space Assigned Numbers Auth.
- ◆ Delta-DOR
- ◆ Timeline Data Exchange
- ◆ XML Standards and Guidelines

### Typical Mission Profile



#### Spacecraft Onboard Interface Services

- ◆ Onboard Wireless WG
- ◆ Application Supt Services (incl. Plug-n-Play)

#### Space Link Services

- ◆ RF & Modulation
- ◆ Space Link Coding & Sync.
- ◆ Multi/Hyper Data Compress.
- ◆ Space Link Protocols
- ◆ Next Generation Uplink
- ◆ Space Data Link Security
- ◆ Planetary Communications
- ◆ Optical Coding and Mod

#### Cross Support Services

- ◆ CS Service Management
- ◆ CS Transfer Services
- ◆ Cross Supt Service Arch.
- ◆ Generic Gnd-to-Gnd File Transfer

#### Space Internetworking Services

- ◆ Motion Imagery & Apps
- ◆ Delay Tolerant Networking
- ◆ Voice
- ◆ CFDP over Encap
- ◆ CFDP Revisions

#### Mission Ops & Info Mgt Services

- ◆ Data Archive Ingestion
- ◆ Navigation
- ◆ Spacecraft Monitor & Control
- ◆ Digital Repository Audit/Certification
- ◆ Telerobotics

# CCSDS Areas of Potential Interest for Remote Sensing Programs

## ✦ Sys Eng

Security Techniques for All Missions: Encryption, Key Management, Threats, etc.

## ✦ SOIS

Spacecraft Design Benefits  
Plug-n-Play for Spacecraft Data Busses, Electronic Data Sheets

## ✦ Space Link Svcs

RF & Mod techniques for more bandwidth efficiencies

**Space-adapted Image Compression**, Link level security, Optical (laser) comm for both cross-links and space-ground links

## ✦ CSS

Capabilities to use Comm Assets (antennas) from other agencies and network providers, both transport and automated management

## ✦ SIS - Space Internet

**CFDP = proven onboard file management for remote sensing.** Will be even better when rehosted on DTN (Delay Tolerant Networking). Voice helps ground comm. Video (?)

## ✦ MOIMS

Navigation – Avoid Collisions; Data Archives; SM&C = Service

Oriented Architecture approach to MCCs and migration of apps to onboard spacecraft.

### Spacecraft Onboard Interface Services

- ◆ Application Supt Services (incl. Plug-n-Play)

### Space Link Services

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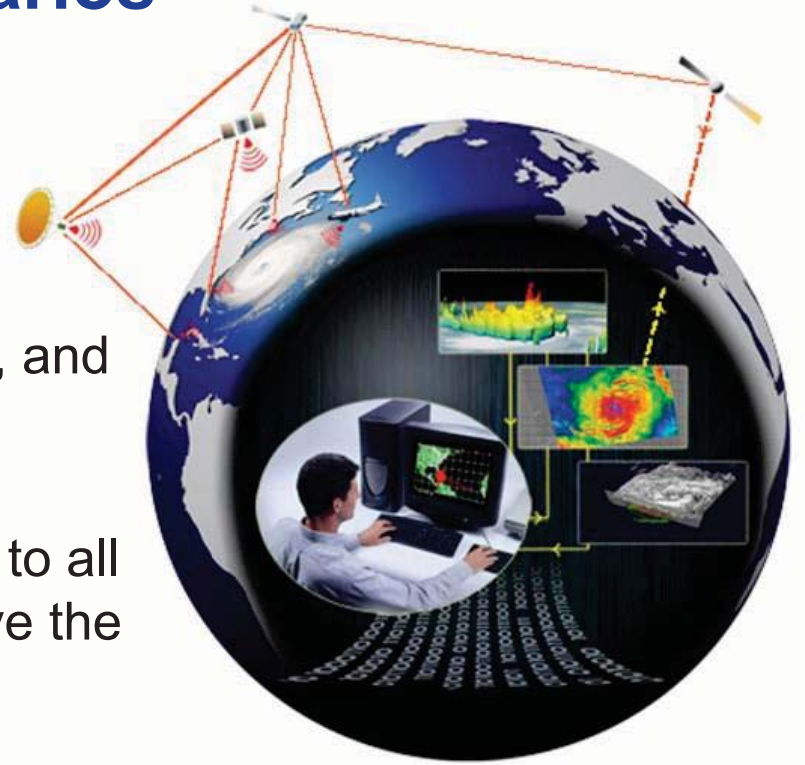
### Spacecraft Info Mgt Services

- ◆ Telemetry Ingestion
- ◆ Navigation
- ◆ Spacecraft Monitor & Control

# Important Scenarios

## ✦ Future SensorWeb Scenario:

- ✧ Multiple Earth-Observing Satellites utilize automated network communications.
- ✧ Built on foundation of CCSDS DTN, AMS, and Space Internetworking standards.
- ✧ Major event (earthquake, volcano) occurs
- ✧ First observation sends automated signal to all satellites, and they simultaneously observe the event



## ✦ Contingency Scenarios

- ✧ Even if your mission does not initially have requirements for international interfaces, you need CCSDS compatibility for emergency support.
- ✧ We have had two scenarios (XMM-Newton and STRS) where a disabled satellite was rescued with assistance from another agency, because of CCSDS compatibility.





# CCSDS Summary

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- ✦ As a minimum, Remote Sensing programs should work for maximum CCSDS compatibility with existing, published standards.
  - ✧ Go to [www.ccsds.org](http://www.ccsds.org), click on “Publications”.
- ✦ Even better, your programs should have their experts become engaged in the development of new CCSDS standards.
  - ✧ To insure future CCSDS standards meet your needs.
  - ✧ Contribute by telecon and electronic reviews, or even attend meetings.
  - ✧ Go to [www.ccsds.org](http://www.ccsds.org), click on “CWE”.